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Original Article

Prevalence of Red-Green Color Vision Defects among Muslim Males and Females of Manipur, India

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Abstract

Background: Color blindness is a common X-linked genetic disorder. However, most of color blinds remain undetected due to absence of proper screening. Our study was to determine the prevalence of red-green color vision defects among Manipuri Muslim males and females. The study could help in decreasing birth of children with this disorder as Muslims commonly perform consanguineous marriage among themselves.

Methods: Unrelated individuals of both sexes (Male-1352, Female-1302) belonging to six different populations were randomly selected and screened for red-green color vision defects using the Ishihara (pseudo-isochromatic plates) test from the area of Imphal East and Imphal west districts of Manipur, which is a small hilly state, situated in the north eastern extreme corner of India sharing an international boundary with Myanmar (Burma).

Results: About 8.73% of males and 1.69% of females were found to be color blind. Among six different populations studied the males of Meitei population shows the highest frequency i.e. 14.93% while Naga population shows the least frequency of 3.75%. Among females, Meitei population again shows the highest frequency of 2.5% and least frequency is shown by Mughal and Naga populations 0.00% as not a single female color blind was found.

Conclusion: Present study shows higher prevalence rate of color blindness as compared to other reported rates of India. Deuteranomaly cases occur in higher percentage than other types of color blindness. The higher prevalence rate observed in Muslims may be due to the hidden effect of consanguineous marriages.

Keywords: Color blindness, Ishihara color test, Manipur, Allele frequency, Protan, Deutan, India

Introduction

The ability to have trichomatic vision distinguishes humans from non-primates. However, inherited congenital color vision defects (CVD), comprising a number of distinct disorders collectively, are relatively common and is often a handicap in everyday life. There is no treatment for color-blindness, nor is it usually the cause of any significant disability. "Color blind" is a term of art; there is no actual blindness but there is a fault in the development of one or more sets of retinal cones that perceive color in light and transmit that information to the optic nerve. It is a sex-linked condition. The genes that produce photo pigments are carried on the X chromosome; if some of these genes are missing or damaged, color blindness will be expressed in males with a higher probability than in females because males only have one X chromosome (in females, a normal gene on only one of the two X chromosomes is enough to yield the needed photo pigments) (1–4). A color-blind person suffers from certain problems in different fields, like generally they are unable to interpret some chemical reactions and the chemical testing kits (5). Color vision deficiencies were detected in 8% of Dutch gastrointestinal endoscopist and affects endoscopist's diagnostic skill. Using a literature search, the results indicated the prevalence of color vision deficiency (CVD) in the medical profession and the medical

skills (6). Clinical laboratory testing is crucial to detecting and diagnosing diseases. Laboratory employees as technicians and technologists examine and analyze the chemical content of fluids, tissues and cells, look for microorganisms, match for transfusions, and use automated equipment and sophisticated, microscope and cell counters. Lab employees also maintain glasswares, instruments, logs and record books, keys to success in this vocation. Color blindness can be a prohibitive factor in some cases (7). Thirteen percent of histopathologist and 10% of medical laboratory technologists in the United Kingdom have deficient color vision which makes more errors in slide interpretation than those with normal color vision. They concluded that histopathologists and medical laboratory technologists and technicians should have their color vision tested (8, 9).

Human color vision is normally trichromatic, and requires at least 3 cone photopigments: 1 from each of 3 well-separated spectral classes. The 3 classes of pigments differ in their relative spectral sensitivities, and are commonly referred to as the blue, green, and red cone pigments (10). There are three kinds of color-vision genes in humans: a "blue" pigment gene on chromosome 7, and "red" and "green" pigment genes at the tip of the long arm of the X chromosome-Xq28 (11, 12). Color vision deficiency is one of the commonest disorders of vision and may be divided into congenital and acquired forms (10). Congenital color vision deficiency (CVD) is an X chromosome-linked recessive, autosomal dominant and very rarely autosomal recessive inherited trait (13). Red-Green defects (Protan and Deutan) show the highest prevalence in the general population (14). Impaired color vision, in the case of red-green color blindness, is genetically determined by X- linked recessive inheritance and thus occurs in males but is transmitted via female and about 8.0% of all women are its carrier (15).

Protan defects include a dichromatic form - protanopia, and a trichromatic form - protanomalous trichromacy. Color awareness of protanopes and pro- tanomalous trichromats is often qualitatively similar, justifying the inclusive term "protan". Similarly, the deutan defects include a dichromatic form - deuteranopia, and a trichromatic form - deuteranomalous trichromacy. Also the color awareness of deuteranopes and deuteranomalous trichromats is usually similar, justifying the term "deutan". The tritan CVD type, a rare autosomal dominant trait has a prevalence of 1 in 15 000 to 1 in 50 000 (that is, 0.002 - 0.007%) of the population (14).

The location of the color-vision pigment genes on or near Xq28 raises the problem of the existence of larger deletions affecting genes that are tightly linked to the color-vision complex. Genes in this general location code for hemophilia A and B, glucose-6-phosphate dehydrogenase (G6PD), the fragile-X syndrome, conduction deafness with stapes fixation, Emery-Dreifuss myopathy, nephrogenic diabetes insipidus, dyskeratosis congenita, chondrodysplasia punctata, an X-linked variety of bipolar affective illness, TKCR (torticollis, keloids, cryptorchidism, renal dysplasia) syndrome, myotubular myopathy, pastic paraplegia, and adrenoleukodystrophy (ALD) (16). There are also some acquired causes for color blindness, such as- damage to the eyes, nerves, brain; some metabolic disorders like diabetes, glaucoma, macular degeneration; chronic illness like- sickle cell anaemia; even exposure to industrial toxins or drug over dose such as- digoxin, barbiturates, anti-tubercular drugs or drug side effects like- Sildenafil (Viagra), Ethambutol, Chloroquine etc (17). Color vision anomaly is also widely used as a genetic marker in the study of human variation in various ethnic groups of India and is frequently cited for investigating 'relaxed selection' (18-20). Being a genetic disorder, the incidence of color blindness, varies from race to race and is different in the different geographical regions of the world inhabited by people of different ethnicity (21).

Our study was to determine the prevalence of red-green color vision defects among Manipuri Muslim males and females.

Materials and Methods

Populations

Manipur is a small hilly state, situated in the north eastern extreme corner of India that connects the

Indian subcontinent to East Asia and South East Asia as a unique narrow passageway and shares an international boundary with Myanmar (Burma). It is bound by China in the north, Bangladesh in the south west, Bhutan in the north west and Burma in the east and is also isolated from the rest of India, both geographically and economically (22).

Manipuri Muslims comprise 8.32% of the total population according to the 2001 census. They are mostly migrants who started coming to the state in the middle of the 16th century (23). Manipur Muslims are endogamous population which belongs to Sheikh, Syed, Pathan or Mughal castes (24, 25). They have been given different clan names which in Manipuri are called Yumnak or Sagei. The term "Sagei" is a corrupted word of Shaqzi which is an Urdu terminology. About 74 clans are reported in Manipur in the present times (24). Meitei are presumably formed by the admixture of Koomal, Looang, Moirang and Meitei, all of whom are reported to have arrived at different periods of time, coming from different directions and now represent the clans of the community (23). While the Naga are the indigenous tribal population of Manipur, they belong to the Naga-Kuki-Chin group of the Tibeto-Burman linguistic family and are believed to have migrated to Manipur probably between 300 and 400 years ago from Burma (26).

Methods

A cross-sectional, descriptive and analytical study to detect color-blindness by Ishihara color test was used for conducting and analyzing unrelated individuals belonging to both sexes (Male-1352, Female -1302) from the area of Imphal East and Imphal west districts during house to house visit, which were selected on random a priori basis during the day time with the help of volunteers. Survey was also conducted taking Manipuri students studying in Aligarh Muslim University, Aligarh. The following population groups were considered for present study; Muslims with castes – Sheikh, Syed, Pathan and Mughal, Hindu (Meitei) and tribal(Naga), by taking prior informed consent from the individuals, taking into consideration the factors like caste, consanguity, age, religion etc.

The color vision deficiency was determined using the 24-plate Ishihara's Test of Color Vision. The color vision testing plates are held at 75 cm from the person and tilted at right angle to the line of vision. The test was done in a properly lighted place. The person was asked to read the numbers seen on the test plates 1 to 17. An assessment of the reading of plates 1 to 15 determines the normality or defectiveness of color vision. If 13 or more plates are read correctly, the color vision is regarded as normal. If only 9 or less than 9 plates are read correctly, the color vision was regarded as red green deficient. The plates 16 and 17 are used to differentiate protan and deutan types of color vision efficiency. From all persons, an informed consent was taken (27).

Genetic data analysis

The phenotypes were recorded for color blindness for each individual, and the allele frequencies were calculated according to Hardy-Weinberg law using a gene counting method. The level of heterozygosity was calculated using the formula,

Hetrozygosity $= 1- \sum H_o$ Where Ho is the homozygosity of the allele, $H_o = \sum Pi^2$

Results

Color blind people face many difficulties in everyday life, some of the common problems as they discussed during the survey include inability to recognize red and green LED displays on electrical goods, difficulties in driving vehicles. Regarding health there was not much problem except for the difficulties they faced in differentiating primary colors. These deficiencies lead to developing in them a lack of confidence, poor social image i.e. a fear that they are not alike to normal vision individuals. Some individuals (Males) who were denied the military jobs on grounds of color blindness have stopped pursuing further studies, while very few of well educated families have taken this in a positive way and have started their life in a new way. The general population was mostly unaware of the difficulties that color blindness can cause; besides they have neither undergone any screening test. The overall data shows that out of the six

population taken only Naga tribes have the least prevalence of color blindness in both males and females showing that they are living in close conformity with nature and they seem to be adopting less urban style since color vision defects would be more damaging to primitive populations, as they have to depend upon game for their subsistence, and in which, therefore, the full vision power for differentiating colors is vital (19). Since Naga population taken in the present study are mostly individuals staying in the hilly areas of Manipur where there is less of modern facilities, they are more actively engaged in physical work in comparison to other five populations taken. The other five populations are inhabitants of valley area where modern facilities are available, and the urban population is reported to have more color blindness due to the relaxation of selection operating in them. Hence, the four Muslim caste and the Meitei population have higher prevalence of color blindness.

Phenotypic frequency

The highest phenotypic frequency of color blindness was found among Meitei (8.16%) while the least phenotypic frequency of color blindness was found among Naga population (2.86%). Among males Meitei population shows the highest frequency of 14.93% while Naga population shows the least frequency of 3.75%. Among females also, Meitei populations show the highest frequency of 2.5% and the least frequency is shown by Mughal and Naga population 0.00% as not a single female color blind was found.

The highest phenotypic frequency of Protanomaly was found among Pathan (0.95%). Among males Pathan (2.25%) and in females Sheikh (0.17%) shows the highest phenotypic frequency of Protanomaly. For deuteranomaly, highest phenotypic frequencies were found among Syeds (3.88%), while among males the Meitei (5.97%) and also in the females, again Syeds (1.82%) show the highest phenotypic frequency of deuteranomaly. Highest phenotypic frequency of protanopia was found among Syeds (0.86%). Among males, Syeds (1.64%) show highest phenotypic frequency of protanopia while among females sheikh shows the highest frequency i.e., (0.85%). For deuteranopia, highest phenotypic frequencies were found among Meitei (2.96%). Among males Meitei (5.22%) and among females also Meitei (0.63%) shows the highest phenotypic frequency of deuteranopia. Achromacy is found to be highest among Meitei population (1.11%). Among males Meitei (1.49%) shows the highest phenotypic frequency while in the females also, Meitei (0.63%) shows the highest phenotypic frequency of achromacy (Table 1, 2 and 3).

Table 1: Phenotypic frequency of color blindness among different populations of Manipur

Populations	Male			Female			Combined		
	Normal	Color blind	Total	Normal	Color blind	Total	Normal	Color blind	Total
Sheikh	486 (91.01)	48 (8.99)	534	578 (97.97)	12 (2.03)	590	1064 (94.66)	60 (5.34)	1124
Pathan	202 (90.99)	20 (9.01)	222	298 (98.68)	4 (1.32)	302	500 (95.42)	24 (4.58)	524
Syed	108 (88.52)	14 (11.48)	122	108 (98.18)	2 (1.82)	110	216 (93.10)	16 (6.89)	232
Mughal	170 (94.44)	10 (5.56)	180	90 (100)	0 (0.00)	90	260 (96.3)	10 (3.70)	270
Meitei	114 (85.07)	20 (14.93)	134	156 (97.5)	4 (2.5)	160	270 (91.84)	24 (8.16)	294
Naga	154 (96.25)	6 (3.75)	160	50 (100)	0 (0.00)	50	204 (97.14)	6 (2.86)	210
Total	1234 (91.27)	118 (8.73)	1352	1280 (98.31)	22 (1.69)	1302	2514 (94.72)	140 (5.28)	2674

Table 2: Phenotypic frequency of color blindness among males of different populations of Manipur

Populations	Total No.	Achromacy n(%)	Protanopic n(%)	Deutanopic n(%)	Protanomalic n (%)	Deutanomalic n(%)
Sheikh	534	5(0.94)	3(0.56)	6(1.13)	9(1.69)	25(4.68)
Pathan	222	2(0.90)	2(0.90)	6(2.70)	5(2.25)	5(2.25)
Syed	122	1(0.82)	2(1.64)	2(1.64)	2(1.64)	7(5.74)
Moghul	180	1(0.56)	1(0.56)	1(0.56)	2(1.11)	5(2.78)
Meitei	134	2(1.49)	2(1.49)	7(5.22)	1(0.75)	8(5.97)
Naga	160	0(0.00)	0(0.00)	0(0.00)	0(0.00)	6(3.75)

Table 3: Phenotypic frequency of color blindness among females of different populations of Manipur

Populations	Total No.	Achromacy n(%)	Protanopic n (%)	Deutanopic n(%)	Protanomalic n(%)	Deutanomalic n(%)
Sheikh	590	1(0.17)	5(0.85)	3(0.51)	1(0.17)	2(0.34)
Pathan	302	1(0.33)	2(0.66)	0(0.00)	0(0.00)	1(0.33)
Syed	110	0(0.00)	0(0.00)	0(0.00)	0(0.00)	2(1.82)
Moghul	90	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)
Meitei	160	1(0.63)	0(0.00)	1(0.63)	0(0.00)	2(1.25)
Naga	50	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)

Allele frequency

The highest allele frequency of color blindness gene was found among Sheikh being 12.5 %, and the least among Naga being, 3.75 %. Among males, Meiteis show the highest allele frequency of color blindness gene i.e., 14.9 % and the least was shown by Naga 3.75%. Among females, Sheikhs show the highest allele frequency i.e., 14.26 % and the least was shown by Mughal and Naga i.e., 0% (Table 4).

Heterozygosity

Among females, the highest heterozygosity condition was found among Meitei, 26.61 % and the least was among the Moghul and Naga i.e., 0 %. While Sheikh, Pathan and Syed shows the heterozygosity frequency of 24.45%, 2.648% and 3.63% respectively.

Table 4: Allele frequency of color blindness among different populations of Manipur

Populations	Male		Female		Combined	
	C	c	C	c	C	c
Sheikh	0.910	0.089	0.857	0.143	0.88	0.13
Pathan	0.901	0.099	0.987	0.013	0.95	0.05
Syed	0.94	0.060	0.982	0.019	0.93	0.07
Mughal	0.96	0.037	100	0	0.96	0.04
Meitei	0.851	0.149	0.842	0.158	0.93	0.07
Naga	0.96	0.038	100	0	0.96	0.04
Total	0.913	0.087	0.983	0.017	0.947	0.053

Discussion

Our present study provides a comprehensive database on the occurrence of color blindness in the Manipuri population especially with regard to Manipuri Muslims. The knowledge of the prevalence of the trait in this religion is important, since they perform consanguineous marriage among them-

selves and might result in the birth of children with this disorder (28). In the present study we have avoided inbreeding individuals but from the data obtained, Muslims show higher prevalence of color blindness in comparison to Naga population. This shows that there is some hidden inbreeding affect on the population. Early diagnosis of defective color vision can be beneficial for preparing their future family planning and also their lifestyles. In addition, the result of this study will be helpful to create awareness among the parents and general public about screening of color vision defects in apparently healthy children (29). Color blindness is a nonfatal disorder; therefore color blind people usually remain unaware of the defect since their vision is otherwise normal (30). Normal color vision is important for our daily life work such as to recognize the traffic signals during crossing roads or to build career in several professions like- in Military, Pilot, Driver or Chemist etc (31). This study can raise awareness about color blindness among the population, and enlighten affected individuals of possible career options. In Armed Forces, Railways, Police and fire service, Navigation, Civil aviation and Electrical contracting, the color blind individuals, should be avoided for safety of the public.

Congenital color blindness cannot be treated since this type of color defects are non pathologic, incurable, and remain constant throughout life (10); although several therapies have been proposed (e.g. 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 (32). Optometrists give colored spectacle lenses or a single red-tint contact lens to be worn over the non-dominant eye. Although this may improve discrimination of some colors, it can make other colors more difficult to distinguish. A 1981 review of various studies to evaluate the effect of the X-chrom contact lens concluded that, the lens may allow the wearer to achieve a better score on certain color vision tests, it did not correct color vision in the natural environment (33). A lot of applications for iPhone and iPad have been developed to help color blind people to view the colors in a better way. Many apps launch a sort of simulation of color blind vision to make normal people to view and understand how the color blinds see the world. Other ones allow a correction of the image grabbed from the camera with a special "daltonizer" algorithm. In 2003, a cybernetic device called eyeborg was developed to allow the wearer to hear sounds representing different colors (34). Achromatopsic artist Neil Harbisson was the first to use such a device in early 2004, the eyeborg allowed him to start painting in color by memorizing the sound of each color. In 2012 at a TED Conference, Harbisson explained how he could now perceive colors outside the ability of human vision (35).

Therefore, an early diagnosis, education, and awareness of this condition can guide young individuals to opt other careers and prevent marriages between the individuals with the disorder (10). Thus it can help in providing a new path to young generation without developing any frustration and disappointment in their life. Moreover, till date no work has been done on Manipuri Muslims with different castes on the prevalence of color blindness and results of this study can be useful for future study of comparing the prevalence rate in different ethnic populations of Manipur.

In the present study, the overall percentage of color blindness was found to be 5.28%. Color blindness in the present study was found to be at higher percentage among males than in females which is common universally, as majority of the affected individuals are males. The abnormality being inherited as a X linked recessive character, males are mostly affected and females usually act as carriers (15). Around 8.73 % of males were found to be color blind in the present study. In a previous study among male population in Belgium, 8% of the samples were affected. The average red-green deficiency among males in the United States was also estimated at 8%. The prevalence rate in Turkey is 7.33% and in China it is 6.5% (10). The present prevalence rate when compared with different populations of India is found to be higher than that from Jammu and Kashmir population, among urban populations—Pandits and Dogras (7.2%) and Sudra – the

scheduled caste (7.5%). Among the populations with Mongoloid affinities from the states of Nagaland, Mizoram, Tripura and Sikkim of Eastern Himalayan region, the prevalence rates are low as 0.00%, 0.018%, 0.015%, 0.026%, respectively where quite high frequencies are observed among Apatani (10.4%), Tangsa (5.5%), Miji (5.6%), Gallong(4.3%). Asian males have a prevalence of color vision defects of 4.9% compared to 0.6% in females. The frequency of color-blindness is around 8% among Europeans. It is between 1% and 6% with an average of 4 % among Africans; between 2% and 7% with an average of 5.6 % in South-West Asian populations; between 3% and 6% in populations of East Asia and South-East Asia and about 1% among South American Indians and Eskimos (18). Among the six populations taken in the present study Meitei male population shows the highest color blindness prevalence rate of 14.93% followed by Syed population (11.48%) belonging to Muslim religion, while the Naga population shows the least prevalence rate of 3.75%.

Females in the present study show the prevalence rate of 1.69%. It is reported as 0.8% in Aligarh and Simla (21), 0.1% in Patiala City (30). No data is available for comparison from Manipuri female population. The prevalence rate of female color blindness as reported from different parts of the world are Denmark (0.54%), Greenland (0.4%), Ethiopia (0.2%), Italy (0%), Newzealand (0%), Iraq (3.2%), Iran (0.43%), Jordan (0.33%), Spain (0.75%) and Saudi Arabia (0.75%) (14).

Among the six populations taken in the present study, Muslims belonging to caste Sheikh, Pathan, Syed and Moghul shows overall prevalence rate of 5.34 %, 4.58%, 6.89% and 3.70% respectively, while Meitei and Naga shows 8.16% and 2.86%. The high prevalence rate in Muslims may be due to higher frequency of consanguineous marriages, which is commonly practiced among Muslims as stated by different authors in previous work on Muslim populations (21). Meitei population shows the highest prevalence percentage of 8.16% which appears to indicate a gradual increase in the prevalence of color blindness among the Meitei population as Singh (1991) reported about 4% and 3% of color blindness among Manipur Meitei and Assam Meitei respectively (36). The possible reason for the increase in color blindness rate might be due to large number of migration by Manipuri people over the past few years, to different parts of India, indirectly leading to increase in the rate of exogamous marriages with non-manipuri populations. Naga tribe shows the lowest prevalence rate of color blindness i.e., 2.86%. It has been observed that overall frequency of color vision defects has been observed quite low among scheduled tribe groups (traditionally food-gatherers and hunters and later occupied in shifting cultivation and as agricultural laborers) from all the zones in India followed by scheduled caste groups (about 90 per cent of scheduled castes are agricultural laborers) which is followed by caste groups. Thus the present observation perfectly fits into the hypothesis proposed earlier (19, 20). Other researchers suggested that increase incidence of color blindness among the Caucasians may be due to difference in the molecular pattern of X chromosome of color vision genes. Furthermore, it is also suggested that Caucasians have comparatively fewer green pigment genes than that of the Asians or American blacks (10).

Present study also shows that deuteranomaly cases occur in higher percentage than other types of color blindness. Overall prevalence rate of Protanomaly, Deuteranomaly, Protanopia, Deuteranopia is 17.14%, 54%, 8.57% and 20% respectively. 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. Besides this, only congenital color blindness was found. Similar findings are also reported by several authors (37).

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 (38). The government must take initiative for color blind awareness among the different population in the state to guide the color blind individuals towards right path and increase awareness of the

needs of color blind people in everyday life. In this condition, color blind school children must be given career advice which includes information as to which careers they may find to be difficult or impossible to follow and also help school children 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 upon how to treat color blind children in a school environment.

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 programmes regarding career choices and jobs for color blind individuals.

Ethical considerations

Ethical issues (Including plagiarism, Informed Consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc) have been completely observed by the authors.

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