

Assessment of Colour Blindness and Erythrocyte G6PD Enzyme Status among the School Children of Dhaka City

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Abstract

Background: Visual impairment due to colour blindness is an unusual suffering of the school children. It may be associated with erythrocyte G6PD enzyme deficiency. **Objective:** To find out defective vision due to colour blindness in apparently healthy school children and to measure erythrocyte G6PD enzyme level among them. **Methods:** This cross sectional study was carried out in the Department of Physiology, SSMC from 1st July 2007 to 31st June 2008. Five hundred (500) apparently healthy school children of old Dhaka, age ranged from 6 to 12 years irrespective of gender and race was selected as study population. Colour vision test was done by Ishihara's test. Erythrocyte G6PD enzyme was measured among the colour blind children. All the results were compared to that of children with normal colour vision. **Results:** Five male children were detected to have partial red-green type of colour blindness. The percentage of colour blindness was statistically not significant ($p > 0.05$) when compared to that of children with normal colour vision. Mean erythrocyte G6PD enzyme level of colour blind children was significantly lower ($p < 0.05$) compared to that of children with normal colour vision. Presence of G6PD enzyme deficiency among the colour blind children did not show any clinical abnormalities might be due to different non symptomatic G6PD variants. **Conclusion:** Visual defect due to colour which blindness particularly red-green type might be present in apparently healthy school children associated with erythrocyte G6PD enzyme deficiency.

Key words: Colour blindness; Erythrocyte G6PD enzyme.

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Introduction:

Colour blindness is a genetic disorder found in children since birth¹. It is the inability of the individual to differentiate or to identify the primary colours. Colour blindness was first described by John Dalton in 1798 who himself was colour blind². Colour blindness may be total or partial³. However, partial colour blindness is more common than total colour blindness^{3,4}. Etiologically, colour blindness can be congenital or acquired⁴. Congenital colour blindness is more common⁴ and transmitted as X-linked recessive disorder⁵. Gene for colour vision is located within the Xq28 chromosome⁶. Majority of the affected individuals are males⁷. There are also some acquired causes for colour 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 etc⁸⁻¹⁰.

Colour blindness is a nonfatal disorder therefore; colour blind people usually remain unaware about the defect since their vision is otherwise normal¹¹. Normal colour vision is important for our daily life work such as to recognize the traffic signals during road crossing or to build carrier in several professions like- Military, Pilot, Driving or Chemist etc. Children are able to recognize colour at the age of four years¹² and usually by this age they start to go to school. Being a colour

blind child they undergo lots of difficulties doing activities like drawing or paintings, sorting blocks of different colours and also during using of computers. More often they are embarrassed by their teachers as well as classmates for their undetected disabilities. Besides, it is also life threatening for them concerning any emergencies like during road crossing or laboratory exposure. Therefore, identification of colour vision defects at the early childhood age is very important. Various tests are there to detect colour blindness, such as- The lantern test, the Holmgren's wools test, the Farnsworth- Munsell 100 hue test etc¹³. But most suitable of them in clinical practice is the Ishihara's pseudo isochromatic test plates¹³.

Among different types of colour blindness, red-green type is more common due to same identical DNA sequence of red and green receptors¹³. Even though, blue blindness is rare but may present in metabolic disorder like Diabetes Mellitus¹⁴.

Study on the incidence of colour blindness has been carried out worldwide. It shows an interesting variation between male and female as well as among the different populations according to their epidemiologic and social features¹⁵. Several studies revealed that, the prevalence of colour blindness is highest among the Caucasians than those of other populations ranging from 7.0% to 9.0% for Caucasian males and 1.0% for Caucasian female¹⁶. Whereas, those for black male and female it is only 4.0% and 0.8% respectively¹⁷. Incidence of colour blindness from the various Asian countries ranges between these two extremes¹⁸. Again, moderately higher prevalence of colour blindness about 4% to 8% is observed in Muslim population^{18,19}.

The frequency of incidence of colour blindness varies from 3.0% to 5.0% in different parts of India, Pakistan and Chinese populations^{1,18-20}. Furthermore, lower rate of colour blindness always exists in primitive communities especially

among the hunters and food gatherers compared to those of the civilized communities²¹.

Glucose-6-Phosphate Dehydrogenase enzyme deficiency is an X-linked recessive disorder and there are more than 200 structural variants of G6PD^{22,23}. However, most of them are harmless and are not associated with any clinical or hematological abnormalities²²⁻²⁴. Several research works reported about the presence of colour blindness associated with Glucose-6-Phosphate Dehydrogenase (G6PD) enzyme deficiency²³⁻²⁷. However, presence of colour blindness with normal G6PD enzyme level among different populations were also reported by some of the researchers^{28,29}.

Early diagnosis of defective colour vision is beneficial to colour blind population for preparing their future planning lifestyles. In addition, the result of this study will be helpful to create awareness among the parents and general publics about screening of colour vision defects in apparently healthy children. Moreover, result of this study can also be utilized as data base for future study. Studies on colour blindness with G6PD enzyme deficiency is again carried out in different countries²³⁻²⁹. But no such available data about colour blindness and their erythrocyte G6PD enzyme status has yet been reported in our country.

Considering all these aspects, this study was designed to detect the presence of colour blindness in apparently healthy school children of 6 to 12 years age and to measure Erythrocyte Glucose-6-Phosphate Dehydrogenase (G6PD) enzyme level among them.

Methods

This cross sectional study was carried out in the Department of Physiology, Sir Salimullah Medical College, Mitford, Dhaka, during the period from July 2007 to June 2008. For this purpose, five hundred (500) apparently healthy middle class school children aged 6 to 12 years irrespective of gender, race and religions were selected as study

population from four different schools of Dhaka City. Children using medicine on eyes or having any infection, congenital or iatrogenic ocular problems were excluded. The study populations were grouped according to their visual status as group A (control group) consisted of children with normal colour vision and group B (experimental group) consisted of children with colour blindness. Before examination the objectives and benefits of the study procedure were briefly described and informed consent was taken from each of the parents/legal guardians. Permission from ethical committee and other respective authorities were also taken before starting the study among the school children.

Information concerning visual status of the study population was recorded and sociodemographic information was collected from administrative questionnaire. Color-blindness was detected by Ishihara's test (Ishihara 1917). The test was done in day light in adequate illumination. The Ishihara's test plates from 1-25 were shown to each of the children for five seconds to find out the different types of colour blindness and those who could not identify some of the above mentioned plates or identify incorrectly, were further tested with following plate numbers from 27 to 32 particularly to find out whether it was total or partial type of colour blindness.

Erythrocyte G6PD enzyme was measured by spectro photometric method (Randox). The measurement was done among all the children of group B as well as 10 selected children from group A, for comparison. For the measurement of G6PD enzyme, under aseptic procedure 0.2 ml of venous blood was collected from the subjects. After collection the sample of blood was washed with 0.2ml of 0.9% NaCl solution and centrifuged at a rate of 300 rpm for 3 times. The G6PD enzyme

level was then determined by following standard method and calculation.

The results were compared between the groups and data was statistically analyzed by Student's t test (unpaired) and Chi -Square (χ^2) test using computer based SPSS.

Results

The characteristics of the study population according to their sex and religion are presented in Table-I. Male participants were comparatively more than female and most of them were Muslim by religion. Visual status of the study population is presented in figure 1. The percentage of colour blind (Group B) was comparatively lower to that of control (Group A) and the finding was statistically not significant ($p>0.05$). The colour blind children (Group B) presented in Table-II was male in gender and the percentage of partial green colour blindness (deutan) was more than red colour blindness (protan). None of the them had blue colour blindness (tritan). Mean erythrocyte G6PD enzyme levels are shown in figure 2. Mean erythrocyte G6PD enzyme level of group B ($224 \text{ mU}/10^9$ erythrocytes) was significantly ($p<0.05$) lower in comparison to that of group A ($249 \text{ mU}/10^9$ erythrocytes).

Table I: Characteristics of the study population (n=500).

Characters	Number n	Percentage (%)
Sex		
Male	290	(58.0)
Female	210	(42.0)
Religion		
Muslim	327	(65.4)
Hindu	172	(34.4)
Christian	01	(0.2)

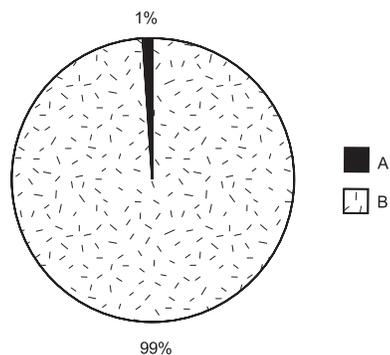


Figure 1: Distribution of the subjects according to their visual status (n=500).

Group A: Normal colour vision (Control).
Group B: Colour blind (Experimental).

Table I: Distribution of the colour blind subjects according to different types of Colour blindness (n=05)

Types of colour blindness	Males number (%)	Females number (%)
Protan		
Partial	01 (20.0)	nil
Total	nil	nil
Deutan		
Partial	04 (80)	nil
Total	nil	nil
Tritan	nil	nil

It is expressed as number and percentage.

Here, **Protan** = Red colour blind, **Deutan**= Green colour blind, **Tritan**= Blue colour blind.

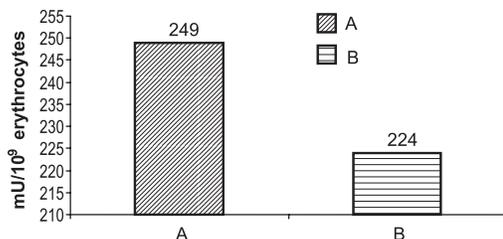


Figure 2: Mean Erythrocyte G6PD enzyme level in different groups (n=15).

Group A: (Control group)
Group B: Experimental (Colour blindness).

Discussion:

In present study the percentage of colour blindness was 1%. The finding is similar to those of other Asian^{1,4,11,19} and African populations^{17,20}. However, the finding is not in agreement to some of the investigators^{16,30}.

Again, colour blindness was found among the males only. Similar observations were made by other workers^{7,30,31}. On the other hand, several studies^{18,33,34} demonstrated dissimilarity to present finding showing that colour blindness is present in both sexes.

The colour blind children of present study were Muslim by religion. It is supported by several investigators^{1,18,19}. However, it is not in agreement to those of other researchers who had observed colour blindness in different religions other than Muslim¹⁵⁻¹⁸. Furthermore, colour blind children of present study were of red-green type and most of them were partially green blind. This finding is in agreement to several researches^{16,31,32}. Though, it is not supported by other group of research workers^{14,33}.

In present study the possible mechanism of colour blindness might be congenital as no other acquired causes were found. Similar findings are also reported by several authors^{6,7,8}. Most of the children of present study lived in Muslim privileged areas of old Dhaka might be the cause of presence of colour blindness among the Muslims only. Again, it is also suggested by several authors^{18,19} that colour blindness is common among the Muslim populations due to frequently practice of consanguinity of marriage among them.

Present study also revealed that most of the colour blind children were partially green blind or deutan. It is suggested by several researchers^{6,7} that green colour receptor is commonly affected than red or blue colour receptors.

Again, the result of present study showed that few of the children with colour blindness had

G6PD enzyme deficiency without any clinical symptoms. Several authors²⁴⁻²⁷ demonstrated similar findings. On the other hand, the finding is not in agreement to some of the investigators^{28,29}. This disagreement may be due to different population with various non pathological G6PD variants³⁵. It has been suggested that G6PD and colour vision genes are closely situated in the same chromosome (Xq28) might be the reason of presence of colour blindness and G6PD enzyme deficiency together in the same person^{25,26}. Therefore, presence of G6PD enzyme deficiency in colour blind children of present study further supports genetic inheritance of following condition.

Present study population was selected from similar socioeconomic status (middle class). The cause for colour blindness in present study group might be genetic cause. Therefore, the association of it with age and socioeconomic factors are unimportant. Again, the percentage of colour blindness in present study is similar to those of Indian, Pakistan and African populations^{1,4,11,19}. The possible reason of this can be explained by Post's hypotheses suggesting increased selection pressure provides a protected environment for normal colour vision gene in primitive populations' like- food gatherers, hunters and agriculturers since they have to depend on their colour vision for their subsistence^{21,37}. Where as, other researchers³⁰ suggested that increase incidence of colour blindness among the Caucasians may be due to difference in the molecular pattern of X chromosome of colour vision genes. Furthermore, it is also suggested that Caucasians have comparatively fewer green pigment genes than that of the Asians or American blacks³⁴. Again, it is also suggested that similarity of present study concerning colour blindness to those of Indian or other populations may be due to occupational, religious, cultural and climatic similarities with Bangladesh²¹.

It is revealed from the present study that colour blindness is not uncommon in apparently healthy

individuals of our country. Along with it, it is also revealed that presence of erythrocyte G6PD enzyme deficiency in present study group is not the cause of colour blindness but it is the casual factor.

Conclusion

From the result of this study it can be concluded that colour blindness particularly the red green type may be present among the apparently healthy school children associated with erythrocyte G6PD enzyme deficiency.

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