

Prevalence of Color Vision Deficiency among Adult Males from Baghdad Province

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ABSTRACT:

BACKGROUND:

Color Vision Deficiency (CVD) is mostly an inherited trait and is not an uncommon problem. Prevalence of CVD differs among different ethnic and geographic properties of the population that affect their genetic constitution. Ishihara plates remain an internationally accepted tool for screening red-green CVD.

OBJECTIVE:

To determine the prevalence of red-green CVD among adult males from Baghdad province.

PATIENTS AND METHODS:

One thousand and five (1005) adult males were enrolled in this study, using a systematic sampling technique, and were screened for CVD utilizing 24-plate Ishihara plates and re-tested by EnChroma 39-Color plates. All males were residing in Baghdad and the center of Iraq.

RESULTS:

Among all tested males, 948 reside in Baghdad province; of them, 64 showed red-green CVD; thus making prevalence rate of 6.75% in Baghdad province. The deutan/protan ratio was 2.79:1.

CONCLUSION:

Prevalence of CVD among the people of Baghdad lies within the published range for Caucasian males worldwide. Screening children/adult males for CVD from other provinces is recommended.

KEYWORDS: color vision deficiency; screening; ishihara test.

INTRODUCTION:

Color blindness, or better called color vision deficiency (CVD), is the inability to perceive differences between some colors that other people can distinguish. The cause in most instances is a genetic defect but might also be an acquired damage affecting the eye, nerve, or brain or use of certain chemicals. ^(1,2)

Congenital colour vision deficiency (CVD) is an X-linked recessive disorder, less commonly an autosomal dominant and very rarely an autosomal recessive inherited trait. ^(3,4,5,6,7) The genes responsible for red-green CVD are located at the telomeric region of the long arm of the X-chromosome within the Xq28 band ^(4,8,9,10) close to the hemophilia, G6PD and dyskeratosis congenita genes ⁽⁸⁾, while the blue pigment gene resides on chromosome 7. ^(4,5,11)

Red-, green- and blue-sensitive cones are involved in normal human color vision; this is known as the 'trichromatism' and is now the accepted model in humans. ^(11,12)

Clinically, depending on the deficient or absent cone pigments, CVD may be classified into protan (red), deutan (green) and tritan (blue-yellow) types. The protan type could either be a

dichromatic (protanopia), or a trichromatic form (protanomlia). Colour awareness of both forms is qualitatively similar; thus both are included in the term "protan". In a similar description, the deutan type could also be a dichromatic (deutanopia), or a trichromatic (deuteranomlia); both are included under the term "deutan". ⁽⁷⁾

The tritan CVD type is most often an acquired defect, commonly affecting one eye only; a genetic defect (autosomal dominant trait) rarely causes this type. ^(7,13) The complete achromatopsia or rod monochromacy, another type of congenital CVD, is a rare, autosomal recessive trait characterized by loss of function of all cone classes, severe photophobia, nystagmus, reduced visual acuity, and a total inability to discriminate colours. ⁽⁵⁾ The tritan type and the complete achromatopsia occur in about 0.002-0.007% of the population. ^(14,15)

The red-green type is the commonest of all types of CVD, and has a high prevalence in Caucasian populations, usually stated as being 8% of males and 0.4% females and lower in Non-Caucasian populations; ^(16,17,18) Table (1).

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Table 1: Classification & prevalence rates of Color vision defects in Caucasian males ¹⁶

1. Hereditary

- a. *Trichromatism*
 - i. Normal (91.8%)
 - ii. Anomalous
 - 1. Protanomaly (1%)
 - 2. Deuteranomaly (4.6%)
 - 3. Tritanomaly (0.0001%)
- b. *Dichromatism*
 - i. Protanopia (1.2%)
 - ii. Deuteranopia (1.4%)
 - iii. Tritanopia (0.0001%)
- c. *Monochromatism*
 - i. Of the rods (0.003%)
 - ii. Of the cones (0.000001%)

2. Acquired

- a. *Tritan* (blue-yellow) (possibly 5%)
- b. *Proton* (red-green)

Ishihara plate test (38 plates in the original test, and 24 plates in the standard test, and also available in 18-plate short test) is the most universally used test to screen for inherited red-green CVD, and is the most efficient plate test because it incorporates the vanishing, transformation, and the hidden designs as well as qualitatively diagnostic plates that allow differentiation of protan from deutan observers and of the more severely affected dichromats. (9,13,16,17,19,20) Yet, the inherited blue-yellow as well as acquired CVD (most of which are blue-yellow type) are not detected by this test. Nevertheless, it is the most popular and reliable screening test that is widely available. (13) However, it is designed to screen persons more than 7-years of age. (16).

While 2 previous Iraqi studies showed the prevalence of CVD in the north and south of Iraq, data from screening for CVD in Baghdad and the center of Iraq are lacking. So, the aim of the current study is to figure out the prevalence of CVD among adult males from this region of Iraq.

PATIENTS AND METHODS:

This is a cross-sectional study that enrolled 1005 adult Iraqi males from the National Blood Transfusion Bank during the period between June 11th, 2013 and September 11th, 2013 as healthy blood donors. All enrolled subjects were Arabs.

Approval for the study was obtained from the Ethical Committee in the Ministry of Health – Baghdad.

No restrictions were made in the selection of males regarding their age, residence, type of job, or visual acuity status. Participants with diabetes

mellitus, those on chronic drug therapy for more than one month, those with systemic illness or who have history of ocular or head injury which significantly affected vision and those with prolonged UV-exposure were excluded from the study. Needless to say that those who refused to take the test were also excluded from this study.

All participants were tested with the 24-plate Ishihara pseudo-isochromatic plates.

The examiner was tested first for CVD with the 24-plate Ishihara test (IPAD version) on multiple occasions and then re-tested by EnChroma Color Blindness Test (IPAD version) and he passed both tests.

Illumination of the device screen was adjusted at 60% brightness for best viewing condition avoiding reflection of the artificial light on the screen.

The test was carried out for the enrolled subjects in a room with sufficient indirect daylight while lying / sitting comfortably in bed. The Ishihara colour plates were held about 75 cm from the subject and tilted so that the plane of the screen is at right angles to subject's line of vision. All the testing was conducted under binocular viewing conditions. If the subject wears glasses, he is asked to put it on.

Each subject was asked to read the numbers on the first 17 plates of the test and then asked to draw and follow the line with their fingers for plates 18-24.

Generally, each plate was shown for 5 seconds and the subject was allowed to tilt/move his head for best viewing angle; the distance can be changed upon the subject's request.

If a subject shows the characteristic pattern of errors described by the test or the pattern was query, the test was completed to the end (24-plates) and also re-tested with the EnChroma Color Blindness Test, a test similar to the American Optical Company Hardy, Rand, and Ritter (AO HRR) Plates, consisting of 39 colored plates showing a large square containing contrasting colored dots forming certain shapes (circle, square or diamond). The test gives 4 choices for each plate to choose from (a circle ○, a square □, a diamond ◇, or ? for nothing or when unsure).

A combination of results from both tests was used to give the final conclusion about each tested subject.

The subject was labeled as having red-green CVD if he shows the characteristic pattern for red-green CVD on Ishihara test (numeral and diagnostic plates); the type of CVD (being protan or deutan) was determined and the severity was judged by the diagnostic plates of Ishihara test plus information from the EnChroma test results as having either (mild or moderate protanopia / deutanopia) or (protanopia / deutanopia or strong protanopia / deutanopia).

The test results were recorded as type and severity of CVD for each subject along with other information like age, residence, family history of CVD, whether he previously knew about his condition or not, and effect of CVD on his life or job selection.

After excluding an acquired cause, the condition was explained to all affected subjects; the pattern of inheritance was explained in simple words (being an X-linked trait in most cases), the recurrence risk in his family and treatment options was also discussed.

All affected males were advised to seek a confirmatory eye examination for color vision deficiency such as anomaloscopy or electroretinography and were advised to wear visual aids if they find appropriate.

RESULTS:

One thousand and five adult males were enrolled in this cross-sectional study. Their ages ranged from 16-62 years with a mean \pm SD of 33.49 \pm 9.17 years.

None of the enrolled subjects had one of the exclusion criteria, but 3 refused to take the test and thus were excluded.

The vast majority of them, 948 (94.32%) reside in Baghdad Province, the Capital of Iraq while the remaining 57 (5.68%) reside in different provinces around and to the south of Baghdad; Table (2).

From all enrolled males, 72 (7.16%) were found to have CVD. Their ages ranged from (19-53) years; their mean \pm SD was (34.18 \pm 8.63) years with no statistically significant difference between ages of both groups (p-value = 0.5387).

Among those residing in Baghdad, 64/948 males showed red-green color vision deficiency, constituting a prevalence rate of 6.75% in Baghdad; on the other hand, 8 out of 57 from those residing in neighboring provinces showed red-green CVD, with a prevalence of (14.03%); Table (2).

Based on these figures and using the Hardy-Weinberg equation,¹³ the expected gene frequency for heterozygous females (2pq) would be (0.1336), while that for homozygous female (q²) would be (0.005184).

Accordingly, the expected percentage for heterozygous and homozygous females among the people of Baghdad would be (13.36%) and (0.52%) respectively.

From those 72 males with CVD, 53 (73.17%) have deutan (green) type CVD while 19 (26.83%) have a protan (red) type; Table (3).

Those with deutan type (n=53), 28 (52.83%) showed mild CVD while 25 (47.17%) showed moderate CVD; while those with protan type (n=19), 11 (57.89%) showed mild CVD while 8 (42.11%) showed moderate CVD; Table (3).

An acquired cause in all affected subjects was not found and a genetic defect was considered, and was confirmed in those with a positive family history of the disease, Table (4).

Generally speaking, 47 (65.27%) of CVD individuals were unaware of their defect and the diagnosis was made upon testing for the first time; of them 36 (67.92%) were deutans and 11 (23.40%) were protans; 26 of them (55.31%) have mild type CVD.

The remaining 25 (34.73%) knew about their CVD earlier; of them, 17 (32.08%) were deutans while 8 (42.10%) were protans; on the other hand, 15 (60%) of them have moderate CVD.

About half of this group of cases [n=11; (44%)] was diagnosed upon admission to military services. The rest [n=14; (56%)] were known since childhood, Table (4).

Table 2: Distribution of tested males according to their residence with number and percentage of CVD in each province.

Province	No.	%	Normal	CVD	% CVD
Baghdad	948	94.32%	884	64	6.75%
Neighboring provinces	57	5.68%	49	8	14.03%
Total	1005	100%	933	72	7.164

Table 3: Distribution of males with CVD according to the type and severity of their deficiency.

CVD type	Total No.	%	Mild	Moderate
			No. (%)	No. (%)
Deutan	53	72.23%	28 (53.84%)	25 (47.16%)
Protan	19	26.39%	11 (57.89%)	8 (42.11%)
Total No.	72	100%	39 (54.16%)	33 (45.84%)

Table 4: Distribution of CVD males according to CVD type, family history of CVD and time at first diagnosis.

CVD Type	Family history		Total No. (%)	1 st diagnosis No. (%)	Known cases No. (%)	Total No. (%)
	Positive No. (%)	Negative No. (%)				
Deutan	17 (32.08%)	36 (67.92%)	53 (100%)	36 (67.92%)	17 (32.08%)	53 (100%)
Protan	4 (21.05%)	15 (78.95%)	19 (100%)	11 (57.89%)	8 (42.10%)	19 (100%)
Total	21 (29.17%)	51 (70.83%)	72 (100%)	47 (65.27%)	25 (34.73%)	72 (100%)

DISCUSSION:

For screening color vision defects, the question is simply if there is a color deficiency present or not. Since the prevalence of protan and deutan defects are by far the highest in congenital color deficiencies, most screening color vision tests only identify these red-green deficiencies. Screening of color vision deficiencies is usually done with the Ishihara test. In the three studies performed to evaluate the sensitivity of Ishihara pseudoisochromatic test, there was no evidence that Ishihara’s test was less valid than any other screening tests. (25,26,27) Based on these studies, Ishihara test has the mean sensitivity of 96% and the mean specificity of 98.5%28. The Ishihara’s test showed good retest reliability. (21)

The people of Baghdad are heterogeneous in their genetic background as they have many ethnic as well as variable ancestral origins. This observation was documented in two previous molecular studies on the people of Baghdad, which clearly showed the quite heterogeneous mixture of mutations that are different from Iraqi Kurds for example. (22,23)

For this reason, the screening needs to be performed on people from all over the province to cover all possible ethnic and geographic variation in this group of people.

The National Blood Transfusion Center (NBTC), located in the center of Baghdad, where people residing all over Baghdad as well as from the surrounding provinces are referred from different hospitals for blood donation. Such a place can serve this purpose and is suitable to collect

random sample representing the people from this geographic location.

The prevalence of CVD among males can give a relatively accurate estimate about prevalence of CVD among females according to the Hardy-Weinberg equilibrium, since CVD is not a fatal disease, the prevalence should remain constant in a randomly mating population. For this reason, only males were chosen to be screened for CVD. (25)

The results of this study showed a prevalence rate of CVD of (6.75%) in adult males from Baghdad. Two previous studies from Iraq showed a prevalence rate of (8.47%)²⁴ among the children of Erbil City [mostly Kurds] and (8.19) among children from Basrah and surrounding area [Arabs].²⁶ Figures from all three studies lie within the expected range for Caucasian males. (14,16,27)

Other studies from the neighboring countries showed more or less similar figures, e.g. 8.72% in Jordan, (28) 8.18 in Iran (29), 7.33 from Turkey³⁰ but lower figures from different parts of Saudi Arabia (2.3%, 2.93% and 5.85%). (19, 27,31)

In the current study, a higher deutan/protan ratio was noted (53/19) [2.79:1] when compared to Kurd males [Kurd males (1.3:1)]⁽²⁴⁾ but rather similar to usual deutan/protan ratio of 2.2-4.2:1 reported in most other populations, including the Europeans, Far and Middle Easterners. (32)

As more than 65% of all CVD cases were unaware of their defect, this indicates that, in those cases, CVD did not significantly affect the

quality of life of affected individuals and this high figure is not simply because of negligence. ⁽³³⁾ This is supported by the fact that 55.3% of those cases are of mild type.

The deutan/protan ratio in this group is similar to the ratio of CVD individuals as a whole (3.27%) and (2.79%) respectively ($p>0.5$).

Choosing a future career can be an important issue for CVD people as some professions require good to perfect color vision, e.g. airline pilot, air traffic controller, firefighter, police officer, train driver, some ranks in the armed forces, some electrical/electronic engineers; needless to say that some arts (painting for example), teaching arts and interior decoration also require normal color vision. ⁽³³⁾ This was the case in 2 of CVD males in this study as they had to change their jobs because of their CVD. In addition, 11 CVD cases were rejected from certain military / security positions for the same reason.

Surprisingly, all CVD males drive private cars without a problem and some are even truck-drivers. This is explained when we knew that the driver's license in Iraq in the last decade was not performed to all drivers.

One side result was noted in the current study is the fact that as many as 15% of all tested adult males were unlettered and they needed extra help and more time to complete the test.

For this reason, a modified Pseudoisochromatic Ishihara Colour Vision Test Based on Eastern Arabic Numerals was tested and set to screen for CVD among Arabs; yet it's still not widely used and not internationally accepted. ⁽³⁴⁾

For children younger than 7 years, a specially devised 8-plate Ishihara test for unlettered persons based on shapes and tracing pathways has been successfully used on children as young as 4 years old. ⁽¹³⁾

CONCLUSION:

CVD in Iraqi Arab males residing in Baghdad and the center of Iraq lies within the expected range for Caucasian males, as well as the ratio of deutans/protans.

Recommendation:

Screening children and/or adult males from other provinces in Iraq, where data about CVD prevalence are lacking, is recommended.

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