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 (1,050) adult males were enrolled in this study, using a systematic sampling technique, and were screened for CVD utilizing Ishihara plates and re-tested by EnChroma Color plates. All males were residing in Baghdad and the center of Iraq.

RESULTS:

Among all tested males, 974 reside in Baghdad province; of them, 540 showed red-green CVD; thus making prevalence rate of 5,792% in Baghdad province. The deutan/protan ratio was 5,79:1.

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. (1,5)

Congenital colour vision deficiency (CVD) is an X-linked recessive disorder, less commonly an autosomal dominant and very rarely an autosomal recessive inherited trait. (1,3,5,7) The genes responsible for red-green CVD are located at the telomeric region of the long arm of the X-chromosome within the Xq11.2 band close to the hemophilia, G7PD and dyskeratosis congenita genes (7), while the blue pigment gene resides on chromosome Y. (1,3,4,11)

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. (1,3,11)

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 (protanomalia). 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". (2)

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. (2,11) 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, nightblindness, reduced visual acuity, and a total inability to discriminate colours. (2) The tritan type and the complete achromatopsia occur in about 1/37,000 of the population. (11,15)

The red-green type is the commonest of all types of CVD, and has a high prevalence in Caucasian populations, usually stated as being 1/379% of males and 1/14 females and lower in Non-Caucasian populations; (1,3,5,15) Table 1.

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

<table>
<thead>
<tr>
<th>Classification</th>
<th>Prevalence Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hereditary</strong></td>
<td></td>
</tr>
<tr>
<td>a. Trichromatism</td>
<td></td>
</tr>
<tr>
<td>i. Normal (1, 1, 1)</td>
<td></td>
</tr>
<tr>
<td>ii. Anomalous</td>
<td></td>
</tr>
<tr>
<td>1. Protanomaly (1/2)</td>
<td></td>
</tr>
<tr>
<td>2. Deuteranomaly (4, 1/2)</td>
<td></td>
</tr>
<tr>
<td>3. Tritanomaly (4, 4, 4, 1/2)</td>
<td></td>
</tr>
<tr>
<td>b. Dichromatism</td>
<td></td>
</tr>
<tr>
<td>i. Protanopia (1, 1/2)</td>
<td></td>
</tr>
<tr>
<td>ii. Deuteranopia (4, 1/2)</td>
<td></td>
</tr>
<tr>
<td>iii. Tritanopia (4, 4, 4, 1/2)</td>
<td></td>
</tr>
<tr>
<td>c. Monochromatism</td>
<td></td>
</tr>
<tr>
<td>i. Of the rods (4, 4, 4, 1/2)</td>
<td></td>
</tr>
<tr>
<td>ii. Of the cones (4, 4, 4, 1/2)</td>
<td></td>
</tr>
<tr>
<td><strong>Acquired</strong></td>
<td></td>
</tr>
<tr>
<td>a. Tritan (blue-yellow) (possibly 1/2)</td>
<td></td>
</tr>
<tr>
<td>b. Proton (red-green)</td>
<td></td>
</tr>
</tbody>
</table>

Ishihara plate test (8 plates in the original test, and 14 plates in the standard test, and also available in 4-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. 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. However, it is designed to screen persons more than 7-years of age.

While 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 adult Iraqi males from the National Blood Transfusion Bank during the period between June 11th and September 11th 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 14-plate Ishihara pseudo-isochromatic plates. The examiner was tested first for CVD with the 14-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 1/2 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 1/2 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 8 plates of the test and then asked to draw and follow the line with their fingers for plates 4, 5. 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.
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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 (Ishihara 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 \( \tau^4 \) 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 \( \bigcirc \), a square \( \Box \), a diamond \( \Diamond \), 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 protanomalia / deutanomalia) or (protopia / deutanopia or strong protanomalia / deutanomalia). 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 11 to 15 years with a mean \( \pm \) SD of 13.47 \( \pm \) 2.17 years. None of the enrolled subjects had one of the exclusion criteria, but \( \tau \) refused to take the test and thus were excluded.

The vast majority of them, \( \tau^7 \) (143.7\%) reside in Baghdad Province, the Capital of Iraq while the remaining \( \tau^7 \) (5.3\%) reside in different provinces around and to the south of Baghdad; Table (1).

From all enrolled males, \( \tau^7 \) (11.1\%) were found to have CVD. Their ages ranged from 13 to 16 years; their mean \( \pm \) SD was 14.08 \( \pm \) 2.53 years with no statistically significant difference between ages of both groups (p-value = 0.545).

Among those residing in Baghdad, \( \tau^7 \) (14\%) males showed red-green color vision deficiency, constituting a prevalence rate of 14\% in Baghdad; on the other hand, \( \tau^7 \) out of \( \tau^7 \) from those residing in neighboring provinces showed red-green CVD, with a prevalence of (14.7\%); Table (1).

Based on these figures and using the Hardy-Weinberg equation, \( \tau \) the expected gene frequency for heterozygous females (\( \tau^7 \tau^7 \)) would be (0.1\%), while that for homozygous female (\( \tau^7 \)\) would be (0.001). Accordingly, the expected percentage for heterozygous and homozygous females among the people of Baghdad would be (14.7\%\%) and (0.04%) respectively.

From those \( \tau^7 \) males with CVD, \( \tau^7 \) (11.1\%) have deutan (green) type CVD while \( \tau^7 \) (13.4\%) have a protan (red) type; Table (1).

Those with deutan type (\( n=\tau^7 \)), \( \tau^7 \) (18\%) showed mild CVD while \( \tau^7 \) (14\%) showed moderate CVD; while those with protan type (\( n=\tau^7 \)), \( \tau^7 \) (27\%) showed mild CVD while \( \tau^7 \) (23\%) showed moderate CVD; Table (1).

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, \( \tau^7 \) (14.7\%) \% of CVD individuals were unaware of their defect and the diagnosis was made upon testing for the first time; of them \( \tau^7 \) (11.1\%) were deutans and \( \tau^7 \) (13.4\%) were protans; \( \tau^7 \) of them (20.7\%) have mild type CVD.

The remaining \( \tau^7 \) knew about their CVD earlier; of them, \( \tau^7 \) (11.1\%) were deutans while \( \tau^7 \) (13.4\%) were protans; on the other hand, \( \tau^7 \) (6\%) of them have moderate CVD.

About half of this group of cases [\( n=\tau^7 \); (14.7\%)] was diagnosed upon admission to military services. The rest [\( n=\tau^7 \); (6\%\%)] were known since childhood, Table (1).
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 performed on people from all over the province to diagnose CVD and time at first diagnosis.

<table>
<thead>
<tr>
<th>Province</th>
<th>No. (%)</th>
<th>% Normal</th>
<th>CVD</th>
<th>% CVD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baghdad</td>
<td>1,241</td>
<td>45,4%</td>
<td>45</td>
<td>1,1%</td>
</tr>
<tr>
<td>Neighboring provinces</td>
<td>1,241</td>
<td>45,4%</td>
<td>45</td>
<td>1,1%</td>
</tr>
<tr>
<td>Total</td>
<td>1,241</td>
<td>45,4%</td>
<td>45</td>
<td>1,1%</td>
</tr>
</tbody>
</table>

The results of this study showed a prevalence rate of CVD of (1,1% in adult males from Baghdad. Two previous studies from Iraq showed a prevalence rate of (1,1% among the children of Erbil City [mostly Kurds] and (1,1% among children from Basrah and surrounding area [Arabs]. Figures from all three studies lie within the expected range for Caucasian males. Other studies from the neighboring countries showed more or less similar figures, e.g. (5,7% in Jordan, (4,3% in Iran, (6,7% from Turkey, but lower figures from different parts of Saudi Arabia (1,4%, (5,7% and (6,5%).

In the current study, a higher deutan/protan ratio was noted (4,3/1,1) when compared to Kurd males [Kurd males (1,7)] but rather similar to usual deutan/protan ratio of (1,7) reported in most other populations, including the Europeans, Far and Middle Easterners.

As more than (2% of all CVD cases were unknown of their defect, this indicates that, in those cases, CVD did not significantly affect the
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quality of life of affected individuals and this high figure is not simply because of negligence. This is supported by the fact that 5% 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 (7, 8) and (7, 9, 10) respectively (p>0.05).

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. This was the case in 4 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 10% 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. For children younger than 7 years, a specially devised A-plate Ishihara test for unlettered persons based on shapes and tracing pathways has been successfully used on children as young as 4 years old.

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.

REFERENCES:
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