

Discrimination of Ishihara Test Plates Through a Red Filter

Kırmızı Filtreden İshihara Testi Levhalarının Ayırt Edilmesi

Kırmızı Filtre ve Ishihara Testi / Ishihara Test Through Red Filter

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Özet

Amaç: Bu çalışmanın amacı renkli görme kusuru olan kişilerin kırmızı filtre ile Ishihara Renkli Görme Test performanslarını değerlendirmektir. Gereç ve Yöntem: Otuz renkli görme kusuru olan erkek olgu ve 30 normal erkek olgu çalışmaya dahil edildi. Renkli görme bozukluğu olanlarda ve normal olgularda ortanca yaş sırasıyla 26,5 yaş (min-maks: 17-61) ve 28,0 yaş (min-maks: 18-60) idi. Gruplar arasında yaş bakımından istatistiksel olarak anlamlı fark yoktu (p=0,62). Bireyler filtresiz olarak, gözlük camı deneme setindeki kırmızı filtre ve kırmızı asetat kağıdı ile İshihara Renkli Görme Testi, 38 levha baskısı ile muayene edildi. Bulgular: Kırmızı filtreden baktıklarında renk görme kusuru olan olguların tamamı levhaları sıfır hata ile okudu (p<0,001) ve normal renk görmeye sahip olguların performansında belirgin bir artış gözlendi (p=0,014). Her iki gruptaki olgular tüm Ishihara levhalarını hatasız okudu. Tartışma: Renkli görme bozukluğu olan olguların kırmızı filtreden baktıklarında İshihara Testini hatasız tamamlayacaklarını sonucuna ulaşıldı.

Anahtar Kelimeler

İshihara Testi; Renkli Görme Bozukluğu; Renkli Görme Kusuru; Kırmızı Filtre; Renkli Görme Simülasyonu; Dikromat

Abstract

Aim: The aim of this study was to investigate the Ishihara Color Vision Test performance of color-deficient subjects through red filters. Material and Method: Thirty color-defective male subjects and 30 color normal male subjects were included in the study. The median age was 26.5 (min-max: 17-61) and 28.0 (min-max: 18-60) years in color deficient and in normal subjects respectively. There was no statistical difference between the groups regarding the age (p=0.62). All the subjects were tested with the Ishihara Color Vision Test, 38-plate edition without filter and with red filter from trial lens set and red acetate paper. Results: Through red filters all of the color vision defective subjects were able to read the plates with zero error (p<0.001) and the performance of color normal subjects also increased significantly (p=0.014). In both groups, all the subjects were able to read all the plates without errors. Discussion: It was concluded that the color-deficient subjects can perform Ishihara Test without errors through red filter.

Keywords

Ishihara Test Plates; Color Vision Deficiency; Red Filter, Color Vision Malingerer; Dichromacy

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Color deficiency is a frequent condition affecting 8% of males and 0.5% of females in the population [1]. The fact that tinted lenses improve the Ishihara test scores led us to design this study to investigate the performance of color deficient subjects through a red filter of trial lens set and through red acetate paper since we didn't come across studies evaluating the effects of these filters in PubMed [2-5].

Material and Method

Setting: An ophthalmology clinic in a tertiary care centre.

Study design: This prospective study was approved by the institutional board and conducted according to the tenets of the Declaration of Helsinki. Informed consent was obtained from all the subjects after explanation of the nature of the study.

Instrumentation: Visual acuity was measured using a Snellen chart and recorded in decimal notation. Color vision was tested with the Ishihara Color Vision Test, 38-plate edition for red-green deficiency, as the Ishihara test is the only legal test officially recognized by the military; police; private security, pilot and sailing licensing institutions and private employees in Turkey. Ishihara test was used to identify red-green color-defective subjects.

The Ishihara test was performed binocularly. The study subjects were instructed to read numerals within 3 seconds. The plates were held at a distance of approximately 75 cm perpendicular to their visual axis. Four errors or fewer were accepted as normal; five errors or more were accepted as deficient.[2] The subjects were instructed to read the Ishihara test without any filter, through a red filter (MSD trial lens set, MSD S.r.l, Busto Arsizio, Italy) and through red acetate paper (four sheets placed over each other). The spectral transmission curves of the filters are shown in Figure 1.

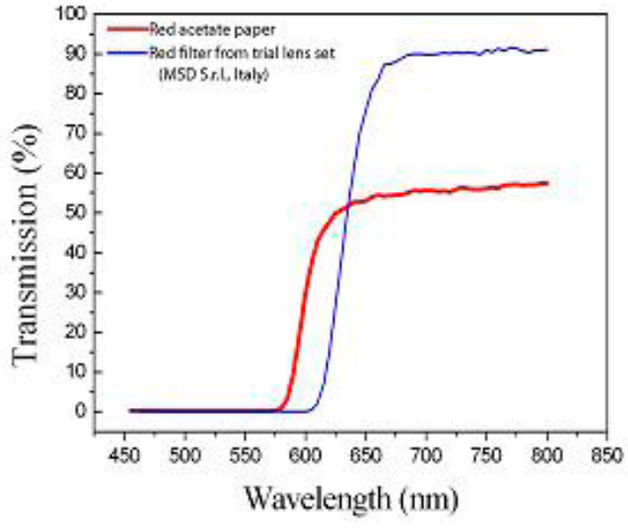

Figure 1: Spectral transmission graph of the red filter and acetate paper

Illumination: The illuminant (HG-E27PHW3AH1W40R-C, Hangrand Tech Co., ShenZhen, China) with characteristics of 6006-6500 K color temperature, 400-600 lux illuminance at 1 m was used for lightning.

Scoring the Ishihara test: The alteration, the vanishing and the hidden digit plates were used for scoring. Results were recorded in terms of error rates. Every plate was given 1 point. Every digit of double digit plates was given 0.5 point.

Study population: Thirty consecutive color-normal subjects (Control Group) and 30 consecutive color-deficient subjects (CVD Group) were enrolled in the study. All screened subjects were male.

Inclusion criteria were best corrected visual acuity at least 1.0 (in decimal notation), literacy, and healthy eye.

Exclusion criteria were best corrected visual acuity less than 1.0, illiteracy, any ocular disease or a history of disease, or use of systemic drugs.

Main outcome measures were age, number of errors made with and without red filter.

Data analysis: For data analysis, SPSS (Statistical Package for Social Sciences) for Windows 13.0 software (SPSS Inc. Chicago, USA) was used. A $p<0.05$ was accepted as a level of statistical significance. Normality distribution of continuous variables (age, error scores) was tested by Kolmogorov-Smirnov test, Histogram and P-P plots. Since age and error scores were distributed abnormally descriptive statistics for age and error scores were expressed as median (minimum-maximum). The difference between the groups was analyzed with Mann-Whitney U test. The difference between scores with and without red filter was calculated using the Wilcoxon test, for each group.

Results

The median age in color-deficient and in normal subjects was 26.5 (min-max: 17-61) and 28.0 (min-max: 18-60) years, respectively (all male). There was no difference between the groups regarding age ($p=0.62$). According to diagnostic plates, in the CVD Group 13 (43.3%) were deutans and 17 (56.7%) were unclassified. No clear protans were detected. Except for the three subjects who had refractive errors less than 1.00 diopter of cylindrical or spherical error, all the others were emetropic. The visual acuities of all patients were 1.0 in both eyes.

The error scores of the CVD Group without and with red filter are shown in Table 1.

Table 1. Median Ishihara test error scores made by colour normal and colour deficient subjects with and without red filter

		Median	Minimum	Maximum	
Without filter	Colour normal group	0.00	0.00	2.00	p<0.001
	Colour defective group	17.25	6.00	20.00	
Through red filter†	Colour normal group	0.00	0.00	0.00	p=1.00
	Colour defective group	0.00	0.00	0.00	

†Through red filter from trial lens set (MSD S.r.l., Italy) and through 4 sheets of red acetate paper placed over each other

The error scores without red filter was significantly different between the groups ($p<0.001$). Through the red filters, all the subjects from the CVD and Control Groups were able to read all the plates without errors.

In the CVD Group the error scores without red filter and with red filter were significantly different ($p<0.001$). In the Control Group,

the error scores without filter and with red filter were also significantly different (p=0.014).

The red filter was very effective in improving the Ishihara scores and through it, not only the CVD subjects but also color normal subjects were able to read all the plates with zero error.

All the subjects obtained same scores through red filter from trial lens set and through acetate papers.

Discussion

The objective observation of our study was that the red-green CVD subjects can read all the Ishihara plates through a red filter just as normal subjects do. The subjective observation was the happiness that appeared in the faces of the CVD subjects when digits of the Ishihara plates became visible.

It was shown that X-chrome and ChromaGen contact lenses, and other types of red filters significantly reduce Ishihara error rates in CVD subjects [4-10]. We observed that the red filter in the trial set and red acetate paper not only reduce but also minimize the errors to zero.

Hovis at al.'s [9] and Diaconu et al.'s [10] studies explain the effect of colored filters on the tasks based on achromatic contrast. The digits on the Ishihara test are equal in luminance with the background and are defined only by chromatic contrast. The red filter absorbs short to mid wavelength light causing the digits containing red points to become brighter to the protanope which makes them distinguishable by the luminance mechanism [9]. Consistent with this report recently Diaconu et al [10] demonstrated that the red filter changes the color perceptions in the protanopes and normal trichromats, and provided an explanation that helps us to understand the effect of the red filter. According to that study red filter improves the ability of protanopes to detect long-wavelength light by converting the color contrast to luminance contrast [11]. Similarly another study demonstrated that contour discrimination in dichromats improved by different spectral filtering for two eyes [12].

The red filter modifies color perception not only in protanopes but also in deuteranops and in normal subjects [8, 11]. ChromaGen lens causes improvement in the Ishihara test in deutans and protans [8]. Through short to mid wavelength absorbing filters, both protans and deutans gain improvement in the Ishihara test [9]. In all of our subjects, [13 (43.3%) deutans, 17 (56.7%) unclassified CVD subjects and 30 color normal subjects], significant improvement in Ishihara test plates occurred. When combining with the results of the Diaconu et al.'s [10] and Hovis et al.'s [11] studies, it can be concluded that the red filter can improve the Ishihara test results in deutans, protans and in normal trichromats.

Two types of color vision malingering exist [13]. The first type malingerers conceal a congenital color vision defect. The second type malingerers pretend to have a color vision defect. In our daily practice we come across the color-normal subjects serving as armed security staff pretending to have CVD in order to shift to unarmed security staff, or obtain early retirement. It also appears as a challenge with armed security staff at the time of renewal of their licenses. The CVD subjects, examined prior to the acceptance of the regulation stating that armed security must be a color-normal with Ishihara test, already have their licenses for armed security. At the renewal examination, when a subject with a pre-existing license appears CVD arouses doubt as to whether the subject is a real CVD or a malingerer. The identification of CVD from malingerers can be a challenging task. The most common test used is the failure to read the discrimination plate. However, advanced malingerers can learn this fact and add it to their malingering affect and read the discrimination plate while ignoring reading the others. At this stage, we think that "red filter malingering test" can be helpful. The denial of reading the plates through the red filter can indicate the malingerers pretending to have a color vision defect, when poor central vision or co-existing conditions affecting color perception are eliminated [14-18]. The benefits of proposed "red filter malingering test" need to be evaluated separately in a study including subjects pretending to have CVD.

Although there is no cure for CVD and the improved performance seen on clinical tests with the filters may not reflect the improvement in everyday life, and do not provide normal color discrimination, a red acetate paper which is easily available and very cheap can be very useful in daily life which will be an extremely cheap alternative to tinted contact lenses and glasses (e.g., reading a web page designed with characters that can not be discriminated by color-deficient subjects) [3-5]. It would be good advice for all color-deficient subjects to keep red acetate paper near their computers.

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Competing interests

The authors declare that they have no competing interests.

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