Comparing the effectiveness of printed versus iPad Ishihara plates in diagnosis of congenital red-green color deficiency in Thai male population.

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Objective: *To compare the Effectiveness Between Ishihara plates on iPad Air2 and traditional printed standard Ishihara test for screening red-green color vision deficiency in male population*

Design: *Case-control Diagnostic Study*

Methods: *Male volunteers (patients and relatives) from Thammasat hospital and students from grades 3-6 at Buengkhaoyorn school, Pathumtani province were recruited. All volunteers were examined for red-green color deficiency by standard Ishihara test, and Pseudochromatic color test application on iPad Air2 at 100% brightness in a room without or less sunlight, comparing the two results to determine the latter test's effectiveness in screening red-green color deficiency.*

Results: *A total of 313 selected volunteers were examined, age ranged from 6 to 80 years old. Fourty - nine participants who tested positive for red-green color vision deficiency using the Standard Ishihara test were also positive for red-green color vision deficiency using the Pseudochromatic color test application in iPad Air2. Another 264 volunteers who tested negative red-green color vision deficiency using the Standard Ishihara test also had negative red-green color vision deficiency using the Pseudochromatic color test application in iPad Air2. The sensitivity, specificity and positive predictive value for the Pseudochromatic color test was 100%, 100% and 100%.*

Discussion: *The Pseudochromatic color test is a suitable substitute to the standard Ishihara test when used on an iPad Air2 at optimal lighting conditions. The use of free standard Ishihara test substitute applications on tablets may be suitable for screening color deficiency in resource limited settings.*

Keywords: *color vision testing, cone dystrophy, color deficiency, Ishihara test*

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Introduction

The normal capacity to perceive colors in humans requires the ability to receive and discriminate colors by cone cells in the retina. Cells of the retina are classified into 3 types, according to sensitivity in perceiving primary colors red green and blue. Abnormalities in particular type of cone cells may decrease the ability to perceive colors in normal lighting conditions, this state is also known as color deficiency.

There is a system of classification for color deficiency, based on which colors are unable to be perceived. Color deficiency may be congenital or acquired. Existing literature reported red-green color deficiency as the most common form, which is a congenital x-linked recessive condition. As a result, females are often found to be carriers whilst manifesting as the condition in males. Studies from around the world suggest color deficiency is found in 5-8% of males and 0.5% of females, with some variation of this proportion around in each region.[1-5] A previous study in Thailand found prevalence of color deficiency in Thailand to be 7.7% in males and none in females, similar to findings from studies abroad.[6]

A commonly used screening method to detect color deficiency in modern practice uses a Pseudosochromatic chart, also known as the standard Ishihara test (figure 1.) which consists of color plates designed to confuse patients with red-green color deficiency. For example a patient with red color deficiency would be unable to perceive red and blue-green dots if there is a red number on a blue-green background, or an affected patient may not be able to perceive the number indicated on the plate. Present literature suggests the sensitivity, specificity and positive predictive values for the standard Ishihara test are 100%, 97% and 97% respectively.[7]

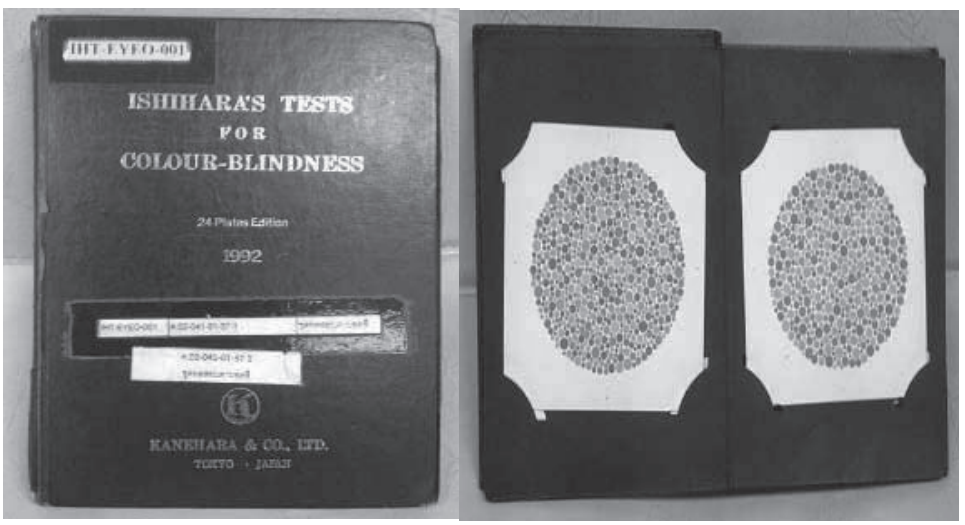

Figure 1. Standard Ishihara Test

Although the standard Ishihara test is a commonly used method of screening[7] it is an expensive method, costing 10,000 Thai baht, hence it is only used in large hospitals. In current practice it is common for healthcare workers to download the standard Ishihara test applications onto tablets such as the iPad or smart phones such as the Pseudochromatic color test which is created to assist in screening (figure 2). This cost reducing improvisation is an interesting prospect, assuming these applications can reliably screen for color deficiency as the standard Ishihara test.

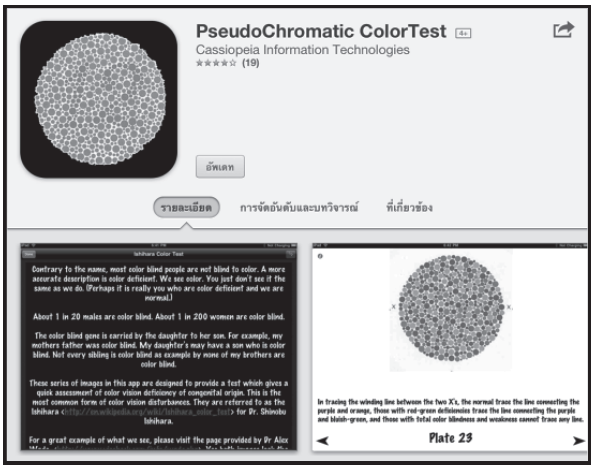

Figure 2. illustrates Application Program Ishihara Color Test on iPad

Methods

313 Male patients and relatives at Thammasat University Hospital and Primary school children from 3rd- 6th grade at Bungkhaoyorn, Pathumthani province are recruited for color deficiency screening between June and December 2016. The sample size was calculated to be 49 patients with positive standard Ishihara test result, and 264 patients with negative standard Ishihara test result, with sufficient statistical power of 0.9, in proving the sensitivity and specificity of the Pseudochromatic Color test free application comparable to the standard Ishihara test using a one sample test of proportion.[8]

$$n = \left[\frac{z_{1-\alpha/2}\{p_0(1-p_0)\}^{1/2} + z_{1-\beta}\{p_A(1-p_A)\}^{1/2}}{p_A - p_0} \right]^2$$

Each patient undertakes a standard Ishihara test (24 plate variant, 17 plates consisting of numbers) and screened for red-green color deficiency if 4 or more plates containing numbers are incorrectly interpreted. Patients are then asked to take the Pseudochromatic color test, a free application available on iPad Air2 which displays the same pictures of the standard Ishihara test, at 100% brightness in a room with less sunlight. We shuffled pictures in Pseudochromatic color test to reduce recall bias in every patient. We standardized the screen contrast at 100% and used the same methods as the standard Ishihara test. The results are analysed for sensitivity and specificity.

Inclusion Criteria

Subjects who are able to verbally communicate and interpret Arabic numerals who have given written consent, and does not have any ophthalmological past history hindering the ability to perceive numbers in both types of tests.

Exclusion Criteria

Subjects who decline to agree to the terms stated in the written consent form

Results

313 male patients aged 6-80 underwent both the standard Ishihara test and the Pseudochromatic color test on the iPad Air2. Results are shown in table 1. All 49 patients who tested positive for red-green color deficiency using the standard Ishihara test also tested positive for the Pseudochromatic color test on iPaid Air2. Consequently, the remaining 264 patients tested negative for both tests as seen in table 2. The results suggest a sensitivity, specificity and positive predictive value of 100% for the Pseudochromatic color test on iPad Air2 using the standard Ishihara test as a standard.

Standard Ishihara Test	Number of patients
Positive	49
Negative	264
Total	313

Table 1 showing results of patients taking the standard Ishihara test

Standard Ishihara Test / Pseudochromatic color test iPad Air2	**Positive**	**Negative**
Positive	49	0
Negative	0	264

Table 2 comparing the results between the standard Ishihara test and the Pseudochromatic color test on the iPad Air 2

Discussion

Our study suggests the Pseudochromatic color test application, a red-green color deficiency screening program on the iPad Air2 on 100% brightness has a screening performance equivalent to that of a the standard Ishihara test with statistical significance. Implying that the application can be used as a substitute to the standard Ishihara test. The use of free standard Ishihara test substitute applications on tablets may be suitable for screening color deficiency in resource limited settings.

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