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Assessment of the Medmont C100 test for colour vision screening of male Saudi Arabians

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Abstract

Purpose: To assess the Medmont C100 test as a colour vision screening tool. *Methods:* One hundred and seventeen young male adults were screened with the Medmont C100, Ishihara plates, and the screening mode of the Oculus Anomaloscope tests. All subjects were tested under constant room illumination, namely that of a day light fluorescent lamp at 200 lux. Inclusion criteria were visual acuities (VA) of 20/20 or better with or without correction and absence of known ocular pathologies. Aided and unaided visual acuities were measured with the Snellen VA chart. *Results:* Five out of the 117 subjects, were found to have red-green colour vision deficiency (CVD) with Ishihara and anomaloscope tests indicating a 4.7% CVD prevalence, while the Medmont C100 test yielded 33 cases of red-green deficiency indicating CVD prevalence of 28%. With the Ishihara test, all five subjects were identified as deutans, while the anomaloscope revealed three as deutans and two as protans, and the Medmont C100 test identified all 33 cases as protans. *Conclusion:* The Medmont C100 test yielded significantly higher prevalence of protan CVD compared with the Ishihara plates and Anomaloscope tests. These findings suggest that caution should be taken when using Medmont C100 test for colour vision screening as it tends to give more false positive results with bias for protans. (*S Afr Optom* 2011 **70**(1) 14-20)

Key words: Colour vision screening, Ishihara pseudoisochromatic test, Oculus HMC Anomaloscope, Medmont C100 colour vision test

Introduction

Colour vision deficiency (CVD) may present as a functional disorder of vision in everyday life, and hence CVD is a public health concern. CVD can be congenital or acquired. The congenital form is known to affect almost 8% of males and 0.5% of females in Caucasian societies[1-4]. Those who have CVD will be able to adapt better and make more informed career choices if they know about their CVD condition earlier. The literature indicates that one fifth to one third of adults with abnormal colour vision are not aware of their CVD[1-4]. This may be due to the fact that colour vision screening is not conducted routinely in eye

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care practices. Also, the uncertainty among health care practitioners about which tests to use, how to interpret the results and the counsel that should be given to patients with CVD might be other reasons. Red-green deficiency is the most prevalent form of CVD, and can vary from very mild (when colour discrimination is not significantly different from that of colour normals and virtually unnoticeable in everyday life) to very severe (when color visual performance can be significantly impaired). In contrast to acquired CVD, the congenital type of colour vision deficiency does not affect other visual functions such as acuity or contrast sensitivity. Also the type and severity of congenital CVD that a person has remains unchanged throughout life, although chromatic sensitivity can decrease gradually with age[2, 3]. The fact that CVD has certain consequences in everyday life, suggests that eye care practitioners should test colour vision of all new patients and provide appropriate advice and counseling to those with abnormal colour vision[4].

Colour plate tests such as the Ishihara test offer a quick and sensitive way of detecting colour vision defects, but not for diagnosis[5]. The Ishihara plates are used as a screening test for red-green colour vision deficiency, and are efficient for that purpose[6]. The Ishihara plates consist of a series of colour-defined numbers embedded within different coloured dots. The plates are designed so that grouping of dots by colour causes a number to emerge from the background that can be recognized correctly by people with normal colour vision, but in the absence of normal colour signals all dots appear falsely as the same hence they are referred to as pseudoisochromatic plates. Therefore, colour deficient individuals either fail to see the number altogether or make mistakes in recognizing the number or drawing correctly[7].

The anomaloscope is a relatively complex and expensive optical instrument for colour vision assessment and is not designed majorly as a screening test. Some regard the anomaloscope as the gold standard in clinical practice for diagnosis, quantifying and discriminating between deutan and protan colour defects. The Oculus Heidelberg Multi-Colour (HMC) Anomaloscope (Oculus Optikgerate GmbH, Wetzlar, Germany) was the type utilized in the present study. The Oculus Anomaloscope is a microprocessor-controlled device for precision diagnosis of colour vision in the red/green area (Rayleigh equation) and in the blue/green area (Moreland equation) with integrated automatic neutral adaptation. The screening mode of the anomaloscope can also be used for colour vision screening as carried out in the present study. This colour vision test system, with its rapid and uncomplicated procedure can be used only as a preliminary test in order to quickly uncover any abnormal colour vision. The examinee is shown five different colour matching presentations in succession by the program; he must evaluate them as identical or different, and then press the *equal* button (on the right of instrument) or *unequal* button (on the left of instrument). Since it is not desirable here that the examinee undertakes a colour adjustment in the upper mixed colour field, only the lower knob is put in readiness for him. He can use this knob, if necessary to change the brightness of the lower comparison field. The result obtained could be normal, protan or deutan. Further objective classification to protanopia, protanomaly, deutanopia and deutanomaly can be obtained with the anomaloscope. The manual can be studied for specific tests if more precise diagnostic information is required (see Manual of Oculus HMC Anomaloscope).

The Medmont C100 test is relatively new and less well known but it has been recommended as a part of the basic battery of colour vision tests[1]. The Medmont C100 colour vision test set is commercially available in Australia. The test measures relative spectral sensitivity using flicker photometry to differentiate protans and deutans. According to Cole (2007)[1], the Medmont C100 owes its origin to Estevez and colleagues[8] who thought of applying the principle of photometry to the assessment of colour vision. The first commercially available instrument using this principle was the OSCAR produced by a Dutch company Medilog, where OSCAR meant "objective screening of colour anomalies and reductions". However, it is no longer produced and the Medmont C100 is now its successor[1]. The Medmont C100 presents a single light generated by two flashing red and green light emitting diodes (LED) that alternate at 16 Hz. Only one of the LEDs is on at a given time but the flash rate is such that the appearance of the stimulus is a flashing yellow light. A single control operated by the patient adjusts the relative luminances of the two LEDs, while keeping the luminance of the resultant flashing yellow stimulus constant. The patient is instructed to adjust the control until the flicker is at a minimum. This occurs when

for the particular patient, the luminances from the red and green LEDs are equal. Protans choose a setting of the control that increases the luminance of the red LED compared to that set by patients with normal colour vision because they have reduced sensitivity to red light. While deutans choose a setting that increases the luminance of the green LED[1]. This study, therefore aims to examine the Medmont C100 test as a valid tool for screening colour vision deficiency by comparing findings from it with those of the Ishihara test and the anomaloscope.

Methods

Participants were recruited through notices on bill boards, personal contacts, and the intranet. The study was conducted between September 2009 and May 2010. The study was approved by the College of Applied Medical Sciences Research Committee, King Saud University, Riyadh. Altogether, 150 young adult male university students were recruited, but only 117 completed the study. Participants were interviewed to identify relevant pathology such as diabetes, amblyopia and any family history, and visual acuity with or without correction was measured. Visual acuity was determined using a Snellen chart in the King Saud University Optometry Clinic room with adequate daylight illumination, for all subjects. The Ishihara colour plate booklet (24-plate version; Kanehara Inc, Tokyo, Japan) was held 60-70 cm from the subject and tilted so that the plane of the page was at right angles to the subject's line of vision. The subject passed the Ishihara colour test if the first 13 plates were identified without error, uncertainty or hesitation (at less than five seconds per plate). All the testing was conducted under binocular viewing conditions. The test was performed three times for all subjects. A subject who made more than three errors between plates 1 and 13 during first and/or second test session was judged to have failed the screening. Every subject considered to have failed the test was retested the third time. Each subject was considered to have CVD if they had more than three errors at two out of three sessions. Such subjects were then shown the Ishihara diagnostic plates (16 and 17) to determine if their CVD was of the protan or deutan type. The answers given by the subjects for each plate were recorded in a special study form containing information such as age, code number, gender, and type of red-green deficiency (if observed). The data were then analyzed, and the CVD cases were classified as protan and deutan types.

The principle behind the anomaloscope method is based on colour matching. The patient looks through a view-finder to see a disk split horizontally into two half fields. The top half of the disk consists of red and green light that can be mixed in different proportions by turning a scaled knob on the right side of the anomaloscope panel. The bottom half of the disk is illuminated with spectral yellow light, the brightness of which can be altered by turning the second scaled knob. The examinee matches the appearance of the two half fields in both colour and brightness by altering the red/green mixture ratio and the brightness of the yellow field. All subjects match the two fields over a range of settings on red/green scale with normal trichromats achieving a match at a consistent mid-scale range of settings indicating normal functioning of green and red photoreceptors in the eye. The matching endpoints and positions on the scale outside the normal settings and the extent of the range determine the type of colour deficiency and its severity. The type of CVD indicated was recorded for each subject. The duration for each subject lasted approximately five minutes.

With the Medmont C100 test (Medmont Pty Ltd, Vermont, Australia), according to the manufacturer, normal room light conditions are suitable but any fluorescent lights which exhibit noticeable flicker should be switched off. The subject was asked to hold the instrument at a distance of about 40 cm, and look at the small circular flickering disk. The subject was instructed to adjust the control knob located on the top of the Medmont C100 case (first to each end of its range such that subject should note the light appears to be flickering quite noticeably in each of both end positions). Then the subject would adjust the knob slowly to a point where the light flicker appears to be at a minimum. The results are decided as follows: 10 light emitting diodes (LEDs) are arranged in a row with a scale from –5 to +5. The two central yellow LEDs are numbered –1 and +1, with the green LEDs spanning +2 to +5 and with red LEDS spanning to –2 to –5. As the adjustment knob is rotated, the LEDs illuminate in turn. If two adjacent LEDs are equally illuminated, the reading would be halfway between the two LED values. Thus, if the two yellow LEDs are

equally illuminated, the reading would be zero. Similarly, if a yellow LED and its adjacent green LED are equally illuminated, the reading would be 1.5. If a patient sets a null point result in the region of +2 to +5 in the green range of the light emitting diodes (LEDs), a decreased sensitivity to green (deutan defect) is indicated. Similarly, a null point setting in the region – 2 to –5 indicates decreased sensitivity to red (protan defect). Normal colour vision will record a null point in the region –1 to +1.

The experimenter records the readings as shown on the indicator at the rear of the instrument. It is recommended that the patient be given two practice attempts at obtaining a minimum flicker point, and the measurements should be repeated at least four times for statistical averaging. The average is then taken as the subject's null points. In the present study for each participant, measurements were repeated five times requiring approximately five minutes. In order to evaluate a clinical test, sensitivity and specificity {Sensitivity = TP / (TP+FN); Specificity = TN / (FP +TN)} are used, and positive/negative predictive values {PPV = TP / (TP+FP); NPV = TN / (TN + FN)} as contained in Table 2 are useful when considering the value of a test to a clinician.

Results

A total of 117 participants (age range; 18 to 25 yrs) with age mean (±SD) of 20.88 years (± 1.76) completed the study. Five (4.27 %) of 117 subjects were found to have congenital red-green CVD in the present study with both the Ishihara and Anomaloscope tests, respectively. However, the Medmont C100 test yielded 33 (28%) of subjects as having CVD. Table 1 shows the CVD classification and number of cases as obtained with the different tests, for example with the Ishihara test, in which all five CVD cases are deutans. The five CVD cases obtained with the anomaloscope yielded three deutan cases, two protan cases, while 112 presented with normal colour vision. Figure 1 shows that with the Medmont C100 results, most of the cases (84 cases: 71.80%) gave a null point in the region between +1.2 to –1.9 (normal region), and about 33 cases (28.20%) have null points in the protan region from –2 to –3.2. The mean (±SD) of the Medmont C100 null point setting is –1.46±1.15; and coefficient of variation is 79%. The histogram (Figure 1) shows that the data are skewed right (meaning that the right tail of the distribution is relatively longer than the left) and not symmetric. In terms of measure of distribution shape for the Medmont C100 null point settings, values of 0.77 and 0.30 were obtained for skewness and kurtosis, respectively, indicating that the data were not normally distributed.

In Table 2, the true negative (TN) results indicate those who passed the Anomaloscope, Ishihara and Medmont C100 tests. False positive (FP) results are those who failed the Medmont C100 test but were normal with the anomaloscope test. The two cells in the bottom row of the matrix show false negative (FN) which represents the number of subjects who passed the Ishihara and Medmont C100 tests but failed the anomaloscope, while the true positive (TP) results indicate those who failed the Medmont C100, Ishihara and anomaloscope tests. Table 3 shows the sensitivity/specificity, positive and negative predictive values from the Medmont C100 test results. The results with the Ishihara test yielded 100% for sensitivity/specificity, positive and negative predictive values, perhaps because the false positives and false negatives were zero, respectively as shown in Table 2.

Table 1. Comparison of the classification and number of cases as obtained with the three colour vision tests.

Classification	Number of cases per test		
	Anomaloscope	Ishihara	Medmont C100
Normal	112	112	84
Protan	2	0	33
Deutan	3	5	0
Total	117	117	117

Table 2. Differences in terms of pass/fail responses between Medmont C100 and Ishihara tests compared to Anomaloscope test results. Percentages indicate number of cases/amount of pass/fail responses out of the 117 subjects.

		Medmont C100 Test		Ishihara Test	
		Pass	Fail	Pass	Fail
Anomaloscope (Standard Test)	Pass (Normal)	81 (69.2%) True Negatives	33 (26.5%) False Positives	112 (95.7%) True Negatives	0 False Positives
	Fail (CVD)	3 (2.6%) False Negatives	2 (1.7%) True Positives	0 False Negatives	5 (4.3%) True Positives

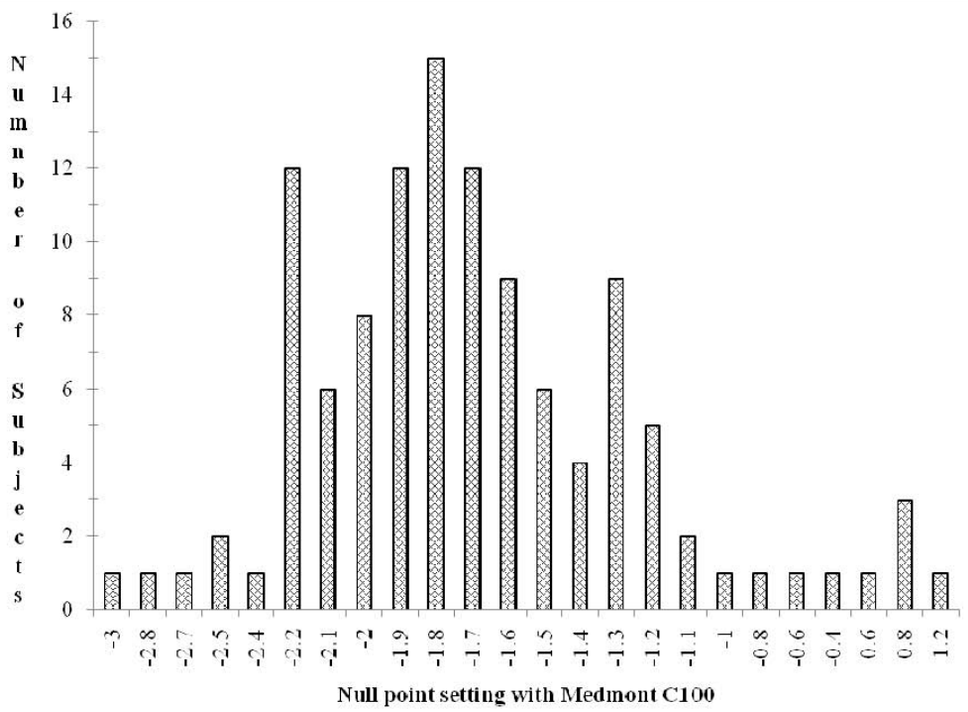

Figure 1. Bar chart of null point responses obtained with the Medmont C100 device and number of subjects per null point. Eighty five (72%) cases out of the 117 subjects gave a null point in the region between 1.2 to –1.9 (normal region), and 33 cases (28%) were in the protan region; – 2 to – 3.2 (no null point setting above –3.2).

Table 3. The sensitivity/specificity and positive/negative predictive values of Medmont C100 test using the screening mode of the Anomaloscope as the standard test for comparison as shown in Table 2. pass/fail responses out of the 117 subjects.

	Medmont C100 Test
Sensitivity	40%
Specificity	72%
Positive predictive value	6%
Negative predictive value	96%

Discussion

The motivation for the present study was based on the premise that the Medmont C100 colour vision system can be used as an additional or alternative test to Ishihara colour plates for quick colour vision screening. There are different types of colour vision tests but adequate knowledge is essential to know their use, the purpose of each method, the availability, and if such test is still recommended or required for educational or occupational (for example, military) purpose. Although various authors[3, 6] have explained that many CV tests are not suitable for

screening, the Medmont C100 test has been recommended for clinical colour vision screening[1]. It may perhaps be argued that the sample size of the present study is too small, but the information presented is clinically useful to the health care practitioners and patients. In the present study a preponderance of protans (protanomaly or protanopia) was observed among the subjects with the Medmont C100 test indicating a higher prevalence of 28% of CVD compared to 4.7% of CVD obtained with both the Ishihara and anomaloscope tests. As mentioned earlier, it is commonly known that congenital CVD may affect as many as 8% of males and 0.5% of females[1, 9]. The Medmont C100 test results in the present study show high standard deviation and 79% coefficient of variation, indicating a relatively high variance of the null point settings for the Medmont C100, which might explain the high false positive results. One of the reasons for involving the anomaloscope in the present study was to use its screening mode as the validation criterion. The shift toward protan obtained with the Medmont C100 test is in close agreement to previous findings by Cole (2007)[1] who reported the mean null point settings to be –1.75, compared to the results in the present study where the mean (±SD) null point setting was –1.46±1.15. Cole (2007)[1] explained the mean null point setting at –1.75 to be due to reduction to red spectral sensitivity, a condition known as Schmidt's sign which is hereditary.

Despite a similarity in the CVD prevalence results with Ishihara colour plates and anomaloscope test, the Ishihara test categorised all the five CVD cases to be deutans, while the anomaloscope differentiates the same five subjects into three deutans and two protans (Table 1). This finding is not surprising, as less than perfect agreement of the Ishihara test with the anomaloscope has been reported by other investigators[10, 11] however the Ishihara test is still one of the most sensitive and most common pseudoisochromatic colour vision tests in clinical use. The findings in the present study show Ishihara test to be 100% in all values, while the Medmont C100 test yielded low sensitivity, relatively low specificity, very low positive predictive value and high negative predictive value (see Table 3). Hence, it is not recommended that Medmont C100 test should replace the Ishihara test for colour vision screening in a standard clinical setting. But, the Medmont C100 may be clinically useful for colour screening especially among those who cannot perform the Ishihara because of the necessity for the patients to know numbers, as well as those patients who cannot respond verbally.

One probable way of comparing results of the Medmont C100 and Ishihara tests is to adjust the cut-off threshold for Medmont C100. For example, with data in the present study, if the cut-off was taken to be –2.5 rather than –2 for the protan range would yield 6 of 117 subjects representing 5% CVD prevalence, then similar prevalence rates would be obtained with both the Ishihara plates and anomaloscope tests, except that the Ishihara test indicates the five cases to be deutans, while Medmont C100 indicates all to be protans. Though this seems to agree with an earlier study which reported misclassifications of red-green CVD by the C100 test with bias towards protans as it is designed to differentiate protans from deutans[12, 13]. It has been mentioned that reducing ambient illumination could significantly decrease average Medmont C100 settings towards red[13], and the drastic difference between outside and inside ambient illumination in the hot sunny Saudi Arabia environment might play a role in the average null point settings as obtained in this study. In conclusion, despite the fact that the Ishihara plate test remains a valid screening test, the need to sub-classify red-green deficiencies into anomalous trichromacy, or dichromacy and protan or deutan requires other approaches such as the anomaloscope, which currently is not in common use in most clinical settings. Though not yielding completely the same results to the Ishihara test, the Medmont C100 test is a portable corollary method for red-green colour vision testing but appears to give significantly more false positive results for protans in the present study. The discrepancies in terms of CVD types as obtained by Medmont C100 and Ishihara tests are a subject for further investigation. Future study with larger sample sizes is required to investigate these findings.

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