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QUANTITATIVE COLOUR VISION DEFECT EVALUATION – LANTHONY TEST AND ITS MODIFIED INTERPRETATION

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SUMMARY

Our aim was to develop quick and exact instrument for examination of color vision defects (CVD). We used Lanthony saturated and desaturated test. Data were evaluated according the Vingrys and King-Smith study. We had together 123 eyes of 86 patients. From all subjects we received these average values: AA 44.32 (min -87.13, max 80.64), TES 13.36 (min 8.84, max 30.30), SI 1.97 (min 1.22, max 5.69) and CI 1.66 (min 1.0, max 3.94). At the base of counting algorithm and average values form saturated and desaturated test we revealed 25 (29 %) patients with CVD. Twelve patients (14 %) classified as CVD+ had dichromacy and all had inborn CVD. Eight patients (9 %) from this group had deutranopia and four patient (5 %) protanopia. Anomaly trichromacy we revealed in thirteen patients (15 %). Eight (9 %) of these patients had inborn CVD. Six (7 %) of these patients had protanomalia, one (1 %) had deuteranomalia and one tritanomalia. We established and specified TES, CI and SI critical values, which was used to dividing patients into specific groups.

Key words: Lanthony test, color vision defect, index of selectivity, index of confusion, total error score

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INTRODUCTION

A large number of tests are used at present for examining colour vision. For screening purposes distinguishing tests are most commonly used, based on the pseudochromatic principle. In practice various modifications to these tests appear – the Ishihara test, Rabkin test, Stilling test etc. Each author of the pseudochromatic test recommends a special procedure upon examination, and the test is also interpreted by a specific method. On the basis of the results produced by these tests we can judge whether or not the subject in question has a colour vision defect and whether this defect is more for red, green or blue light. Unfortunately it is not possible to evaluate precisely whether a colour vision defect is congenital or acquired, and the level of its significance (dichromacy versus anomalous trichromacy).

For a quick evaluation of colour vision we can also use naming tests. During the examination with a naming test the subject must recognise and name the presented colour. In clinical practice we can use "signal light" for this examination. This device contains basic colours – red, green, blue and yellow, which can be further desaturated (mixed with white light). Successful completion of this test is important for drivers – non-professionals, who according to Decree 72/2011 Coll. Should be able to distinguish basic colours. We may presume that a subject who does not pass a pseudochromatic test successfully but is capable of successfully identifying basic colours, including desaturated, suffers from anomalous trichromacy, with the exclusion of dichromacy. In real life the subject has problems with identifying and naming certain colours and shades thereof, but can distinguish and name basic (signal) lights.

Another large group of tests for examining colour vision is mixing tests, which usually mix two basic colours (red and green) for the purpose of obtaining yellow, which can be seen in the referential part of the visual field. In clinical practice we speak of "anomaloscopes". This device enables us to distinguish between a colour vision defect for green and red colour on the basis of an anomaly quotient. If the anomaly quotient is higher than 0.7 and lower than 1.4 it is considered normal. Further (deeper and more extensive) diagnosis of colour vision defect (congenital/acquired defect, anomalous trichromacy/dichromacy) with an anomaloscope can be performed only with great difficulty.

The most specific test for qualitative and quantitative examination of colour vision defects is sorting tests. If it is necessary to perform a complete diagnosis of colour vision, it is possible to use a Farnsworth-Munsell 100 Hue test, which contains 85 discs, and their sorting is performed on an LCD optotype. On the basis of a quantitative analysis according to Vigrys and King-Smith (5) we can divide colour vision defects not only according to type (red/green/blue), or severity (anomalous trichromacy/dichromacy), but also according to whether they are congenital or acquired.

A slight disadvantage of the Farnsworth-Munsell sorting test is its time demand factor. The subject must arrange 85 discs with each eye separately in 4 separate sections of the test. Altogether this therefore concerns sorting 170 discs. The entire examination time is therefore often close to a full hour and is

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thus highly exhausting, especially for older subjects.

For this reason we have attempted to create a new modification of a colour vision test which will be quick but at the same time will enable a reliable quantitative interpretation. The test must also place minimal demands from the perspective of the examined subject. At our centre we used manual modification of the Farnsworth-Munsell test for this purpose, entitled the Lanthony test. The test contains two sets of coloured discs (15 discs twice). One set contains saturated and the second desaturated colours. The referential testing time is around 5 minutes, in which the subject sorts coloured discs according to their logical sequence, plus approximately 2 minutes for evaluation of the test. The test result is converted into electronic format and is quantitatively evaluated on the basis of a calculation algorithm according to the study by Vingrys and King-Smith.

COHORT AND METHOD

At present our cohort contains 123 eyes of 86 subjects. In total 39 of the subjects are women. The probands are included in the cohort at random for the purpose of evaluating their colour vision. At the time of examination, none of the probands had a serious ocular pathology and took the quick Lanthony sorting test. Both eyes were tested separately in a standard (saturated) and desaturated test. The subjects therefore in total arranged 15 discs twice for each eye. There followed a check of the sequence of discs and this sequence was converted into an MS Excel table which contains an algorithm for calculation of partial colour vision parameters according to the study by Vingrys and King-Smith (5). The algorithm is adapted to the Lanthony test with 15 discs.

Following the calculation of partial colour vision parameters (total error score – TES, angle of anomaly – AA, selectivity index – SI and confusion index – CI) it is possible to divide the subjects into a number of groups. It is possible to differentiate subjects with a congenital or acquired colour vision defect, subjects with defective colour vision for red, green or blue, and last but not least it is possible to define the severity of the colour vision defect (dichromacy versus anomalous trichromacy).

Our decision on whether colour vision is defective in a specific subject or whether it corresponds to normal colour vision was based on the TES point score. Probands with a TES score higher than 12 points were classified in the group with defective colour vision (CVD+).

RESULTS

Up to this moment we have obtained the following mean values of colour vision parameters from all the subjects: Angle of anomaly (AA) 44.32 (min. -87.13, max. 80.64), total error score (TES) 13.36 (min. 8.84, max. 30.30), selectivity index (SI) 1.97 (min. 1.22, max. 5.69) and confusion index (CI) 1.66 (min. 1.0, max. 3.94).

On the basis of the calculation algorithm and empirical setting of the limit values we revealed a total of 25 (29%) subjects with a colour vision defect. In 12 (14%) subjects we classified congenital dichromacy. Of these 8 (9%) in this group had deuteranopia and 4 (5%) had protanopia. We detected anomalous trichromacy in 13 (15%) subjects. Eight (9%) of these subjects had a congenital colour vision defect. Six (7%) subjects had protanomaly, 1 (1%) had deuteranomy and 1 had tritanomaly. The representation of the individual types of colour vision defects is illustrated by the graph below. The abbreviation CVD- indicates subjects with no colour vision defect.

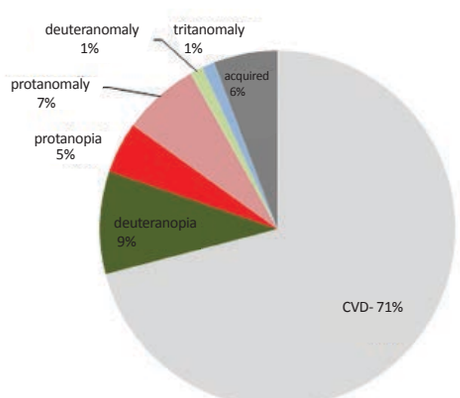
DISCUSSION

During our current measurement we collected data from a total of 86 patients. We detected 25 patients with colour vision defect (CVD). We defined the point criterion of TES as 12, which we obtained through an adjustment of the recommendation criterion from the study by Vingrys and King-Smith (5). We classified probands with a mean TES score from both sections of the Lanthony test (saturated and desaturated variant) higher than 12 into the group with colour vision defect (CVD+).

We divided the probands further according to the confusion index (CI). We classified patients with a CI higher than 2.4 into the group with dichromacy, meaning a loss of the ability to distinguish and name one basic colour (e.g. green). Twelve probands (14%) were included in this group with dichromacy. All had a congenital colour vision defect, which was evaluated on the basis of the selectivity index. The mean selectivity index (SI) for these probands was higher than 1.8. In total we indicated 8 subjects (9%) from this group as deuteranopia and 4 (5%) as protanopia on the basis of the angle of anomaly (AA).

According to Vingrys and King-Smith, the selectivity index (SI) and confusion index are calculated from the relationships between the "large and small arm", which are vectors generated as summary vectors of the partial vectors of the individual coloured discs. Their position and direction is derived from a trichromatic triangle (CIELUV) defined by the International Commission on Illumination – CIE.

We classified thirteen (15%) subjects in the group with anomalous trichromacy, again according to the value of the confusion index (CI lower than 2.4). Eight (9%) of these had a congenital colour defect. Of these, we included six (7%) in the group with protanomaly, one (1%) in the group with deuteranomaly and one in the group with tritanomaly. Five (6%) of subjects were classified in the group with an acquired colour vision defect.



Graph 1 Representation of different colour vision defects in examined sample (n = 86 subjects = 100%)

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Table 1 New criteria for classification of results of Lanthony test using quantitative analysis

Criterion	Veselý et al.	Vingrys and King-Smith (1)
TES	12	11
S-index	1.8	2
C-index	2.4	2.75

In total we detected no colour vision defect according to the above criteria in 61 (71%) subjects, which we classified as CVD-.

The selectivity index and confusion index are very useful parameters for evaluating colour vision defects. However, in certain cases it occurs that classification of colour vision defects may nevertheless be difficult.

Vingrys and King-Smith (5) recommend the use of number 2 for the critical value for the selectivity index SI), and number 2.5 as the critical value for the confusion index (CI). In our study we divided the probands according to the above criteria (see table 1). We selected the number 1.8 as the critical value of the selectivity index, and 2.4 for the confucion index. If a proband had a mean SI value higher than 1.8, we included him/her in the group with a congenital colour vision defect. CI values higher than 2.4 were decisive for the inclusion of a proband in the group with dichromacy. Nevertheless, we recommend further verification of the classification of colour vision defects in individual subjects by means of verbal inquiry concerning a congenital colour vision defect (in the case of differentiation between congenital/acquired colour vision defect) and a test on signals of (basic) slights in order to differentiate dichromacy from anomalous trichromacy.

CONCLUSION

The main aim of our study was to develop a practical clinical test for the classification of colour vision defect. For this purpose we used a simple sorting test (Lanthony test) with fifteen discs twice in standard (saturated) and desaturated (with addition of white light) versions. We converted the results into digital form using MS Excel and evaluated them on the basis of the algorithm from the study by Vingrys and King-Smith (5). In total we had 86 subjects available. All the probands took both variants of the Lanthony test – saturated and desaturated. On the basis of the adjusted critical values of the total error score (TES), selectivity index (SI) and confusion index (CI) we identified 25 patients with colour vision defect. The total error score was higher than 12. Thirteen subjects had anomalous trichromacy and in twelve we diagnosed dichromacy (congenital in all cases).

At present we have the following mean values of certain parameters of colour vision available: Angle of anomaly (AA) 44.32 (min. -87.13, max. 30.30), selectivity index (SI) 1.97 (min. 1.22, max. 5.69) and confusion index (1.66) (min. 1.0, max. 3.94). We are continuously extending the study cohort with the aim of attaining the most precise critical values of TES, CI and SI possible

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