COLOUR VISION IN GROUP OF SUBJECTS WITH AND WITHOUT CHROMAGEN FILTER

Veselý P.[1, 2], Patočková L.[2], Hanák L.[1], Beneš P.[1, 2]

[1]Department of Ocular Pathologies and Optometry, St. Anne's University Hospital, [2]Department of Optometry and Orthoptics, Faculty of Medicine, Masaryk University

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Mgr. Petr Veselý, DiS., Ph.D.
Oddělení nemocí očních a optometrie
Fakultní nemocnice u sv. Anny
Pekařská 53
656 91 Brno
e-mail: veselype@seznam.cz

Summary

Our aim in this study was to prove influence of chromagen filter on color vision quality. Further we wanted to compare quality of color vision in groups of young healthy persons with persons with maculopathy.

In our study we had in total 39 subjects. First group contained 13 subjects with average age 23 years without important eye pathology. In the second group we had 13 patients (average age 68 years) with maculopathy. Third group contained subjects with average age 64 years without important eye pathology. While examination we used sorting tests for color vision: Farnsworth-Munsell test and Lanthony test. Results were evaluated according the Vingryse and King-Smith technique.

We found that average total error score (TES) in young healthy subjects with color chromagen filter doesn't differ from TES value gained from patients with disease of macula (p = 0.86). Further we found that chromagen filter changes color vision in group of young subjects on statistical significant level (p = 0.01). But in clinical view this is not important color vision defect (TES = 107.46 and CI = 1.42). Next study result showed statistically not important difference between the color vision in young healthy patient (average age 23 years) and older healthy patients with average age 64 years (p = 0.58).

Finally we can conclude that green color chromagen filter doesn't have negative influence for dyslectic patients who will use this filter all day. Further we proved that color vision deterioration of patients with macular disease is not important for practical distinguishing of colors but is important clinically for diagnostic purposes. Last but not least we brought result which shows not important difference between young healthy subjects and older subjects (23 versus 64 years).

Key words: Color vision, chromagen lens, total error score, maculopathy

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INTRODUCTION

We know from the literature that colour vision in a patient may be negatively influenced not only by a congenital defect of colour vision, but also by an acquired colour vision defect [8]. Depending on its severity, although a congenital colour vision defect involves certain limitations for the patient (capacity to work or restriction of authorisation to drive a vehicle in accordance with Decree no. 72/2011 Coll.), acquired colour vision defect is clinically more significant. This may be caused by a chronic pathology (e.g. glaucoma, diabetic retinopathy, multiple sclerosis etc.), injury (haemorrhage into eye, retinal detachment etc.), pharmaceuticals (antibiotics, barbiturates, anti-tubercular agents etc.), the effect of chemical substances (carbon monoxide, lead etc.) or ageing (degenerative changes to the retina, opacities etc.) [6].

In the majority of cases, acquired colour vision defects indicate serious systemic or ocular changes, which occur for example as a consequence of the above-stated pathologies. In these cases it is necessary to ensure timely diagnosis and the commencement of correct therapy [10].

In the case of congenital colour vision defects, it is possible to use commercially available systems for correcting colour vision defects (e.g. Chromagen, X-Chrom ad.). These systems are based on absorption of a certain part of the light spectrum. Congenital colour vision defects cannot be entirely rectified, but overall colour perception can be altered by means of appropriate adjustment of light entering the eye (filtering) [1].

Certain types of systems for correction of colour vision defects (Chromagen, Irlen system) have also been proven as suitable aids for patients with specific learning difficulties (e.g. dyslexia). According to the "magnocellular theory", chromagen lenses enable patients to better co-ordinate ocular movements during reading, and thereby enable faster and better quality reading [4, 14].

The aim of this study is to determine how intensively a chromagen glasses lens will influence colour vision without defects. This situation occurs when these special lenses are used for improving reading skills in patients with a specific learning difficulty.

METHODOLOGY

We had 13 probands (Group 1) at our disposal, with an average age of 23 years (SD 0.88), who did not suffer from any significant ocular or general pathology. After examining subjective refraction, we presented the probands with a digital version of the Farnsworth-Munsell test (FM-100 test). The probands actively underwent the test first of all naturally with adequate glasses correction (or without correction with vision of 1.0) without a chromagen filter, and sub-

sequently with binocular use of a green chromagen filter. Below we present the spectral characteristics of the green chromagen filter used.

Thanks to a concurrently conducted study [9], we had the opportunity to compare the results of this examination with patients against those of patients with maculopathy (Group 2, ARMD, DME, CME, total of 13 patients with an average age of 68 years) and older patients (Group 3) without significant ocular pathologies (also 13 patients) with an average age of 64 years. These probands underwent measurement of colour vision with adequate glasses correction on a Lanthony colour arrangement test. The data produced was converted for comparison with the FM-100 test.

The results were transferred to an MS Excel table and statistically evaluated with the aid of the statistical program Statistica version 12 by STATSOFT and MedCalc.

RESULT

For all probands we used a colour arrangement test for examination of colour vision (FM-100 test or Lanthony test), and an analysis of colour vision according to Vingrys and King-Smith [13]. For each proband we therefore obtained a value of the total error score (TES), angle of anomaly(AA), selection index (SI) and confusion index (CI). The total error scores and CI value indicate the severity of the colour vision defect (dichromacy versus anomalous trichromacy). TEST values over 100 points and CI above 2 can be considered significant for colour vision defect. The angle of anomaly indicates the type of colour vision defect. Values from approximately +10 to +50 indicate a colour vision defect in the red region (protanomaly, protanopia), values from approximately -10 to -50 indicate a defect in the green region (deuteranomaly, deuteranopia), and values from approximately -60 to -85 indicate a defect in the blue region (tritanomaly, tritanopia).

On the basis of measuring normality of data (Lilliefors test) we determined normality of data only in the total error score. For a comparison of these quantities we therefore used a parametric T-test, and for the other quantities a non-parametric Wilcoxon test. The level of statistical significance was selected at p = 0.05. Below we present selected results, which we consider the most fundamental.

The above results indicate a statistically significant difference (p = 0.018) in the parameter of the total error score of colour vision in group 1, both with and without the use of a green chromagen filter. This demonstrates that the use of a green coloured filter causes a statistically significant alteration of colour vision. The original average value of TES = 82.15 increased to GTES = 107.46. However, in its result it concerns a TES value which is very low. The average C-index with a green filter increased only from 1.40 to 1.42. For this reason we are of the opinion that this change will not have a negative influence on colour vision in patients who use chromagen filters for improving reading skills.

The above results do not confirm a statistically significant difference between colour vision in young patients (average age 23 years) and older patients (average age 64 years) without pathology according to the T-test (p = 0.585). The

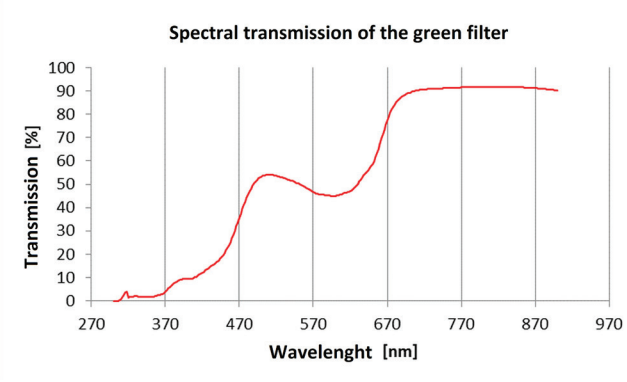

Fig. 1: Spectral characteristics of green chromagen filter.

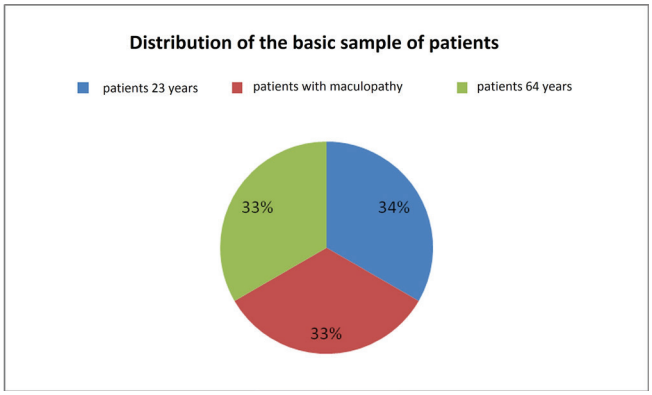

Fig. 2: Distribution of probands in basic cohort. Total 39 probands.

average value of TES = 82.15 therefore does not differ from a statistical perspective from the value of STES = 79.52. We can therefore state that older patients without ocular pathologies had similar quality of colour vision as young patients.

The above results indicate that no statistically significant difference (p = 0,864) exists between the average value in probands with a green filter (GTES = 107.46) and the average value of colour vision in patients with maculopathy (MTES = 105.27). This result indicates the pronounced degree of deterioration of colour vision that may take place in patients with maculopathy. We may therefore compare the deterioration of colour vision in patients with maculopathy to the effect of a green chromagen filter. Acquired colour vision defect in patients therefore need not be practically significant (the patient mostly does not confuse colour shades), but is clinically significant.

DISCUSSION

Algis et al. [2] in their study published the average values of the total error score (TES = 62) and confusion index (CI = 1.0) for a group of 45 probands without colour vision defect. In our cohort, in 13 patients (average age 23 years) without colour vision defect we measured an average value of TES = 82.16 and a value of CI = 1.40.

We were interested in how the colour vision of probands would be influenced by a green chromagen lens upon binocular use. This takes place in patients who use chromagen len-

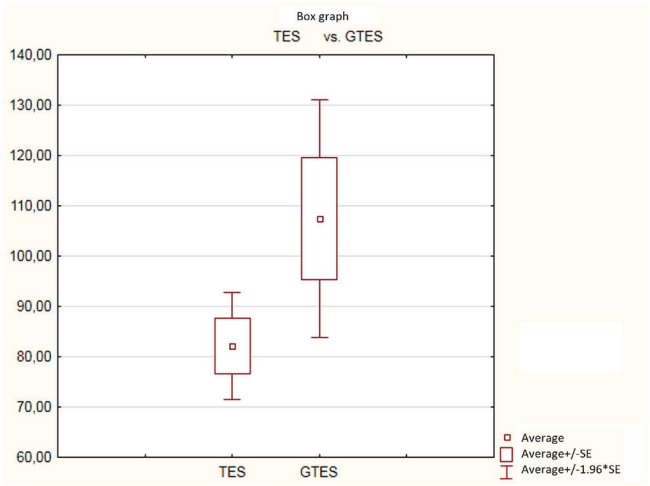

Fig. 3: Box graph for average total error score without green filter (TES) and with filter (GTES).

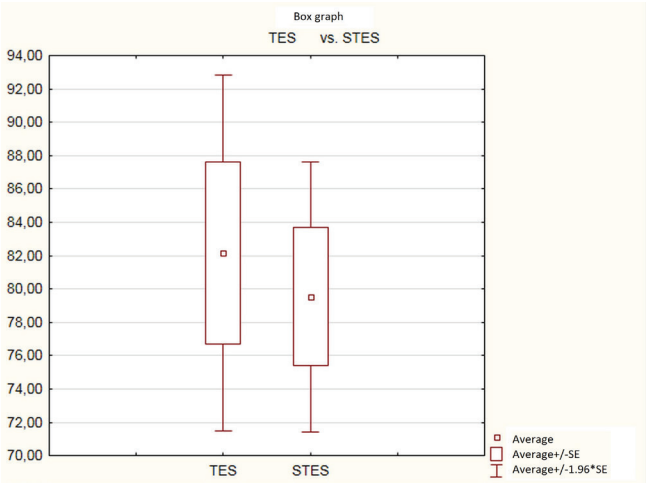

Fig. 4: Box graph for average total error score without green filter (TES) and in older patients (STES).

ses for improving reading skills in the case of specific learning difficulties.

The effect of colour filters on improving the speed and precision of reading in patients with specific learning difficulties has been demonstrated in several studies. For example, Wilkins and Evans [14] state an improvement of 5% in 1/3 of individuals in the examined cohort. Evans et al. [3] recorded an improvement of reading skills in as many as 80 % of probands.

Coloured filters have an effect not only on improving problems with dyslexia, but also on improving visual stress, as demonstrated for example in the study by Kruka et al. [7]. The last survey [11, 12] indicates that dyslexia and visual stress are mutually independent problems.

In our study we verified that although a statistically significant deterioration of colour vision takes place after the use of a green chromagen filter (TES and GTES), the value of average GTES and CI would still remain classified as a slight deterioration of colour vision. This deterioration of colour vision will not have an impact on the perception of ordinary colours. Chromagen glasses may thus be used all day (for example also by vehicle drivers), and not only for reading.

Upon a comparison with a further study [9], we can state that the average value of TES (GTES) in young patients with an average age of 23 years, following the use of a green chromagen filter, attained values which did not differ statistically significantly from the average values of TES (MTES) in patients with maculopathy. From this it ensues that a slight deterioration of colour vision will not have an influence on regular colour perception, but from a clinical perspective it is significant. In the early stages of macular pathology it enables

Table 1: Result of T-test for comparison of TES and GTES

	t-test pro závislé vzorky (Tabulka1) Označ. rozdíly jsou významné na hlad. p < ,05000									
Proměnná	Průměr	Sm.odch.	N	Rozdíl	Sm.odch. rozdílu	t	sv	p	Int. spolehl. -95,000%	Int. spolehl. +95,000%
TES	82,1538	19,63774								
GTES	107,4615	43,43312	13	-25,3077	33,42002	-2,73035	12	0,018255	-45,5032	-5,11218

Table 2: Result of T-test for comparison of TES and STES.

	t-test pro závislé vzorky (tes vs gtes) Označ. rozdíly jsou významné na hlad. p < ,05000									
Proměnná	Průměr	Sm.odch.	N	Rozdíl	Sm.odch. rozdílu	t	sv	p	Int. spolehl. -95,000%	Int. spolehl. +95,000%
TES	82,15385	19,63774								
STES	79,52300	14,92316	13	2,630846	16,92562	0,560432	12	0,585497	-7,59720	12,85889

Table 3: Result of T-test for comparison of GTES and MTES.

	t-test pro závislé vzorky (tes vs gtes) Označ. rozdíly jsou významné na hlad. p < ,05000									
Proměnná	Průměr	Sm.odch.	N	Rozdíl	Sm.odch. rozdílu	t	sv	p	Int. spolehl. -95,000%	Int. spolehl. +95,000%
GTES	107,4615	43,43312								
MTES	105,2760	29,21075	13	2,185538	45,16778	0,174462	12	0,864411	-25,1091	29,48015

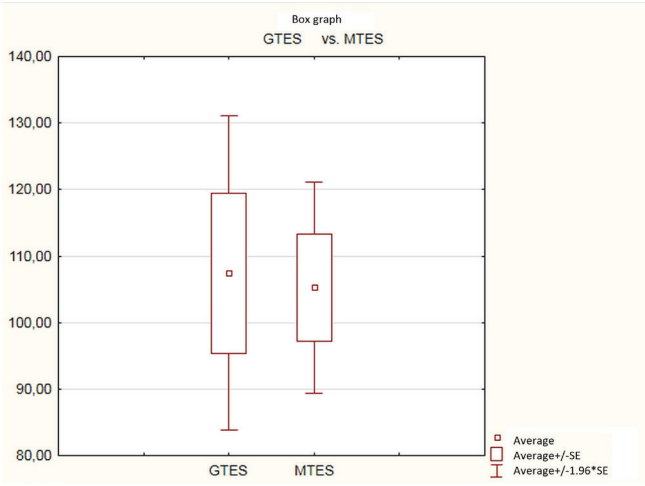

Fig. 5: Box graph for average total error scores with green filter (GTES) and in patients with maculopathy (MTES).

confirmation of changes taking place on the level of photoreceptor elements and other neurons of the retina. As a result, it is important to use a colour vision test on these patients and to monitor any change in their perception.

Upon a comparison of the colour vision of two groups, namely healthy young individuals (TES = 82.16 and average age of 23 years) and older individuals without ocular pathologies (STES = 79.52 and average age 64 years), we determined that no statistically significant difference (p = 0.58) exists between these two groups in terms of quality of colour vision. Another study [5] indicates quality of colour vision during the course of ageing. According to this study, colour vision values TES form a U-curve, with the lowest average value in the period between the ages of 17 and 22.

CONCLUSION

In our study we had a total of 39 probands at our disposal. In all of them we examined colour vision with the aid of colour arrangement tests (FM-100 and Lanthony test). We determined that the average total error score value in young patients (average age 23 years) with a green chromagen filter did not differ statistically significantly from the total error score of patients with macular pathologies (ARMD, DME, CME). We also determined that the average total error score of young patients did not differ statistically significantly from the average total error score of older patients (average age 23 years v 64 years, TES v STES). Last but not least, we demonstrated that upon the use of a green chromagen filter in the group of young probands with an average age of 23 years, a statistically significant deterioration of average TES occurred. The resulting value of average GTES reached 107.46 and CI increased to a value of 1.42, which does not represent a significant deterioration of colour vision from a practical perspective. However, from a clinical perspective this concerns a significant alteration of colour vision.

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