SPORTS MEDICINE

Prospects of Using Photostimulation of the Visual Analyzer in Sports Medicine

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Translated from *Byulleten' Eksperimental'noi Biologii i Meditsiny*, Vol. 152, No. 8, pp. 197-200, August, 2011
Original article submitted April 27, 2010

Experimental studies of photostimulation of the visual analyzer by combinations of red, green, blue, and yellow colors in a pulsed mode were carried out. Significant improvement of a visual acuity is shown after photostimulation course in patients with macular degeneration and degenerative changes of the optic nerve.

Key Words: *photostimulation; visual acuity*

Vision is essential for attaining high results in many athletic disciplines under extreme conditions intrinsic of sports. Visual acuity is one of the criteria for selection, but vision often deteriorates in the course of training and competitions, because of high emotional stress, physical strain and fatigue, and sometimes injuries. Maintenance of the optimal status of the visual function during the critical periods of training and competitions is a pressing problem of sports medicine.

Photostimulation is a method of nonmedicamentous treatment of the eye by light pulses of different colors. A previous study [5] demonstrated the possibility of using this method for the formation of a certain mental and physical status of a human being.

As good vision is essential for athletes, now we studied the prospects of photostimulation as the method for vision improvement.

MATERIALS AND METHODS

Ophthalmologic diseases associated with macular degeneration and degenerative changes in the optic nerve served as models of vision disorders. The choice of these diseases was explained primarily by rather high incidence in highly qualified athletes of transitory and residual disorders in the regional circulation of the retina and optic nerve, underlying the pathogenesis of dystrophic and degenerative processes [1,4,7].

Fifty-six patients of the Head Clinical Hospital of the Ministry of Internal Affairs of the Russian Federation took part in the study. The study conformed to the philosophy of the Helsinki Declaration on Human Rights. The volunteers were mentally healthy, had no organic diseases of the brain, and did not suffer from epilepsy.

The following assumptions were allowed when forming the sample.

The results obtained for each eye of a patient were taken for a unit of observation (85 observations).

Visual acuity was evaluated by the optotype table scale from 0.1 to 1.0 with a 0.1 step. On the other hand, it is common practice if a patient positively reads a certain line of the table and at least half of the lower line, the visual acuity according to both lines is recorded with a dash. The upper line value plus 0.05 was taken for statistical processing. Hence, this sign was assumed to be a continuous value measured with an accuracy of ±0.05. This assumption basically allows the use of the parametrical statistical methods (among other ones) for statistical analysis.

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Cases without object vision (visual acuity <0.1) were excluded from the study and from the total sample.

Cases with visual acuity of 1.0 (12 observations) according to preliminary examinations were excluded from the results of analysis aimed at detection of the positive effect of treatment, but these cases were taken into consideration when evaluating the negative effect. We did so because vision deterioration under the effect of an external factor was possible, while a positive effect of treatment higher than 1.0 was practically useless.

The volunteers were divided at random into 2 groups comparable by clinical characteristics, age, and gender: experimental group (35 subjects, 53 observations) receiving common treatment supplemented by a 10-day photostimulation course and control group (21 patients, 32 observations) receiving common therapy.

Photostimulation was carried out on an AFFZA device (device for photodiagnosis and photostimulation of visual analyzer), created at the All-Russian Institute of Physical Culture and Sports, with programmed interface for regulation of the amplitude-and-frequency and wave characteristics of the light pulses. The wave spectrum ranged from 455 to 655 nm and included pulses of red, green, blue, and yellow colors. Importantly that the short-wave portion of the blue spectrum (<455 nm), involving intense absorption of the most hazardous for the retina photosensitizers [3], was excluded. The photostimulation algorithm ruled out simultaneous exposure of both eyes to light pulses.

The patients received a photostimulation course of 16±2 sessions, carried out no more than 2 times daily. A session lasted for 10 min and corresponded to the protocol including the main cycles of pulses of equal duration with presentation frequencies 8, 10, 14, 16, and 18 Hz, red and green colors during the first half of the session and yellow and blue during the second half of photostimulation session.

Visual acuity was evaluated at the beginning and at the end of observation period on a Zeiss SZP-350 sign refraction projector without correction and with eyeglass correction of ametropia by common methods with consideration for kerato-refractometry data obtained on a Nidek ARK-530 autorefractometer.

Statistical analysis was carried out using SPSS 17 software. In order to choose the criteria for statistical evaluation, the type of the studied signs distribution was studied using the parametrical *T* test with Kolmogorov—Smirnov test (with Liljefors correction). The distribution was considered normal at $p>0.05$. On the other hand, the universally acknowledged rule was also taken into consideration, according to which parametrical methods can be used only at $p>0.2$. If the distribution normality was not reliably confirmed ($p<0.2$), nonparametric methods, including Wilcoxon's test and χ^2 test, were used.

RESULTS

The data on visual acuity with consideration for eyeglass correction were analyzed to check up the normality of distribution (Table 1).

As the significance (Sig) was no higher than 0.2 in all cases, nonparametric statistical methods were used for subsequent analyses.

The treatment did not lead to a drop of visual acuity in any case and resulted in its improvement in many cases (Table 2). Obviously, as 12 cases with the pretreatment visual acuity of 1 were excluded from the sample, the statistical significance was to increase. The reactions of the right and left eyes to treatment were virtually the same for the 73 observations remaining in the sample. This was confirmed by the χ^2 value for 2×2 table. The incidence of observations with visual acuity improvement (25 and 19 for the right and left eyes, respectively) and of cases without changes in

TABLE 1. Kolmogorov-Smirnov's Test for Evaluation of the Form of Distribution of Visual Acuity Values

Parameter		Kolmogorov—Smirnov*			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Before treatment	OD	0.112	47	0.179	0.926	47	0006
	OS	0.188	38	0.002	0.908	38	0.004
	Visual acuity of both eyes	0.125	85	0.002	0.926	85	0.000
After treatment	OD	0.130	47	0.046	0.930	47	0.007
	OS	0.109	38	0.200	0.933	38	0.023
	Visual acuity of both eyes	0.116	85	0.007	0.935	85	0.000

Note. *Liljefors correction. OD: right eye; OS: left eye.

TABLE 2. Wilcoxon's Test for Comparison of Visual Acuity before and after Treatment in the Total Group of Observations

Changes in visual acuity after treatment	N	Mean Rank	Sum of Ranks	Test Statistics[b, c] (b: total group of observations; c: Wilkoxon Signed Ranks)	
Negative Ranks	0a	0.00	0.00	Z	-5.844a
Positive Ranks	44b	22.50	990.00	Asymp. Sig. (2-tailed)	0.000
Ties	41c				
Total	85				
a. Visual acuity after treatment<Visual acuity before treatment					
b. Visual acuity after treatment>Visual acuity before treatment					
c. Visual acuity after treatment=Visual acuity before treatment					

Note. Presents the statistics by Wilcoxon's test for evaluation of therapeutic results in the total sample without consideration for diagnosis, gender, and visual acuity for the right and left eyes separately, including the cases with visual acuity of 1 before treatment.

this value (15 and 14 for the right and left eyes, respectively) served as the data for calculation of this index. The analysis confirmed the zero hypothesis on the absence of significant differences in reactions of the right and left eyes to treatment with the probability p=0.6687 (χ^2=0.180, df=1) at the critical χ^2=3.842 value for p=0.05. Due to this conclusion, subsequent statistical analysis was carried out without dividing the sample by this sign. Patient's gender was also inessential for the incidence of visual acuity improvement. Visual acuity improved in 25 men and remained unchanged in 17; for women these values were 19 and 12, respectively. The χ^2=0.020 (df=1) at p=0.8788 was estimated for this situation. For an opposite assumption with the error probability p£0.05 the critical value of χ^2 was to be ≥3.84.

These results enabled us to focus the subsequent analysis on detection of the treatment efficiency with evaluation of the photostimulation contribution.

Increase in the incidence of improvements after standard therapy was statistically significant (p=0.007), this indicating the reliability and efficiency of this therapy (Table 3).

The resultant Asymp. Sig.=0.000 (Table 4) indicated highly significant difference in visual acuity before and after treatment towards its improvement after photostimulation course, which could indicate an additional contribution of this factor to treatment efficiency. This assumption was justified because estimations of χ^2 for the 2×2 frequencies proportion showed χ^2=9.36 (df=1; p=0.0022). Comparison of this value with the critical χ^2=7.880 (df=1; p=0.005) showed that the calculated value was much higher than the critical one. Hence, the null hypothesis on the absence of differences in the efficiency of the therapeutic protocols was rejected at p=0.0022, i.e. it was proven that photostimulation made an important contribution to improvement of visual acuity.

The mechanism of this result is explained by specific reaction to photostimulation consisting in stimulation of the metabolic processes in the retina [2,3].

TABLE 3. Wilcoxon's Test for Comparison of Visual Acuity before and after Treatment by the Standard Protocol

Changes in visual acuity after treatment	N	Mean Rank	Sum of Ranks	Test Statistics[b, c] (b: standard treatment; c: Wilkoxon Signed Ranks)	
Negative Ranks	0a	0.00	0.00	Z	-2.701a
Positive Ranks	9b	5.00	45.00	Asymp. Sig. (2-tailed)	0.007
Ties	16c				
Total	25				
a. Visual acuity after treatment<Visual acuity before treatment					
b. Visual acuity after treatment>Visual acuity before treatment					
c. Visual acuity after treatment=Visual acuity before treatment					

TABLE 4. Wilcoxon's Test for Comparison of Visual Acuity before and after Treatment Using Photostimulation

Changes in visual acuity after treatment	N	Mean Rank	Sum of Ranks	Test Statistics[b, c] (b: photostimulation; c: Wilkoxon Signed Ranks)	
Negative Ranks	0a	0.00	0.00	Z	-5.224a
Positive Ranks	35b	18.00	630.00	Asymp. Sig. (2-tailed)	0.000
Ties	13c				
Total	48				

a. Visual acuity after treatment<Visual acuity before treatment

b. Visual acuity after treatment>Visual acuity before treatment

c. Visual acuity after treatment=Visual acuity before treatment

Note. Visual acuity was evaluated in patients after combined treatment including standard therapy supplemented by a course of photostimulation.

The alternating mode of photostimulation creating conditions for regeneration of the molecular components in the intricate chain of reactions supporting the functioning of photoreceptors and subsequent transmission of pulses to the cerebral visual cortex, promoted still greater stimulation of the metabolic processes. Further experiments in this direction will, no doubt, provide new data on fine mechanisms of visual functions regulation depending on the stimulus (natural for this sensory analyzer), light.

Hence, our studies have shown that a 10-day standard course of drug therapy leads to a positive clinical effect in patients with the above listed disorders of visual function. Addition of a course of photostimulation to this protocol promoted a significant increase in the number of cases with visual acuity improvement after treatment.

The results indicate good prospects of photostimulation (with the parameters of the light pulse presentation described above) for visual function maintenance at a high functional level in athletes.

REFERENCES

1. S. E. Avetisov, T. N. Kiseleva, Yu. M. Lagutina, and E. A. Kravchuk, Vestn. Oftalmol., No. 3, 26-28 (2007).
2. K. V. Golubtsov, I. G. Kuman, T. S. Kheilo, and N. A. Shigina, Informats. Protsessy, 3, No. 2, 114-122 (2003).
3. G. R. Kalamkarov and M. A. Ostrovskii, Molecular Mechanisms of Visual Reception [in Russian], Moscow (2002).
4. A. Sh. Mukhamed'yanova, R. A. Aznabaev, and M. M. Bikbov, Vestn. Oftalmol., No. 2. 43-45 (2007).
5. M. A. Osipova, V. V. Ar'kov, and A. G. Tonevitskii, Byull. Eksp. Biol. Med., 151, No. 6, 699-703 (2010).
6. A. M. Soldatova, Oftalmol. Zh., No. 6, 273-278 (1992).
7. M. Flammer and M. Mozaffari, Glaukoma, No. 4, 3-15 (2007).