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Objective Characteristics of Accommodation in Present-Day Schoolchildren with Different Levels of Myopia

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Patients and methods: 74 children (10–16 years old), 54 of them with different degrees of myopia and 20 children (control group) with emmetropia were tested on the computer accomodography devise Righton Speedy-K ver. MF-1. The strength of the accommodative response accorded to the presented accommodative stimulus was determined by calculating the accommodative coefficient response (CAO) and the contraction's nature of the ciliary body fibers by determining the microfluctuation coefficient (KMF).

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OBJECTIVECHARACTERISTICSOFACCOMMODATIONINPRESENTDAYSCHOOLCHILDRENWITHDIFFERENTLEVELSOFMYOPIA

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Objective Characteristics of Accommodation in Present-Day Schoolchildren with Different Levels of Myopia

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Results: It has been established that in groups of patients with emmetropia and low myopia, CAO and CMF exceed average normal values. Changes are especially pronounced in the group of children with low myopia. In groups of children with myopia moderate and high degree of CAO is significantly lower than in low myopia and emmetropia, while CMF also exceeds normal values.

Conclusion: In the pathogenesis of progressive myopia in contemporary schoolchildren, spastic component of accommodation, which is expressed in an increase in the accommodation response in relation to accommodation stimulus and a pathological increase in the frequency of accommodative microfluctuations.

Keywords: accommodation; computer accommodation; accommodative microfluctuations; myopia.

I. Introduction

Myopia is a condition in which the spherical equivalent refractive error of an eye is ≤ −0.50 D when ocular accommodation is relaxed [1]. It is the most common anomaly refractions in schoolchildren. In the lower grades, its frequency is 2.4%, in the senior classes - 38.6%. In high schools and lyceums, this figure reaches 50.7%, which is associated with more intense visual loads [2]. Launcher mechanism and one of the most important pathogenetic factors in occurrence and development of progressive myopia are disturbances of accommodation. Majority researchers, describes the weakness of accommodation, which has place in myopic children [3, 4]. Spread in recent years of electronic devises has led contemporary children, not only during school hours, but also in their free time, an intense visual work, which, no doubt, has negatively affected their state of accommodation. Assessment of accommodative functions of children can be carried out both with the use of subjective as well as objective methods evaluate the qualitative and quantitative work indicators of the ciliary body. Subjective research methods, such as determining the margin of relative accommodation or the volume of absolute accommodation, allow you to determine pour quantitative change in dynamic refraction in the process of accommodation. Using objective methods research can be determined not only quantitative, but also qualitative indicators of the work of the ciliary muscle under accommodative load [5].

Purpose of the work is to study the state of accommodative functions in modern schoolchildren with the help of a computer accommodation.

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II. Patients and Methods

The study of the function of accommodation in schoolchildren was carried out day on the basis of a secondary school in the city of Samara, Russian Federation. Educational program in this educational institution does not provide for additional increased loads in the form of intensive forms of training. 54 schoolchildren (108 eyes): 28 girls and 26 boys grow 10–16 years old were examined. All of them were wearing glasses routinely. By the nature of refractive errors, children distributed as follows: 27 people (54 eyes) - with low myopia, 21 people (42 eyes) with moderate myopia, 6 people (12 eyes) - with high myopia. The comparison group included 20 children (40 eyes) with emmetropia. Visual acuity with correction in all patients forged was 0.9–1.0; astigmatic component was within 0.25–0.50 Diopters. All schoolchildren had smartphones or tablet computers that they used at breaks, as well as in free time. Total time spent using electronic gadgets in addition to the school load was at least 2 hours a day. The standard ophthalmic examination included visometry, subjective determination of refraction, and autorefractometry in a state of cycloplegia. Besides, all children made computer accomodography using automatic autorefractometer accommodograph with accommodation function devise Righton Speedy-K ver. MF-1(Japan). The study is carried out monocularly.

In the automatic mode, traditional refractometry is initially carried out, and then the subject is positioned at different distances from the eye, from two meters to twenty centimeters. The accommodograph is given with a visual stimulus, which is called an accommodative stimulus. The accommodograph works in step-by-step mode. In response to the presented accommodative stimulus, the refraction of the examined eye is repeatedly measured, which is considered a research step. A change in refraction is recorded and depicted in the form of a diagram [6].

Developing the idea of the researchers, taking into account the lack of official programs for the mathematical analysis of the histogram obtained from the results of computer accommodation on the Speedy-K ver. MF-1 and the need for a comprehensive quantitative assessment of the work of the ciliary muscle, in order to objectively study the effectiveness of medication, hardware and other effects on the ciliary muscle, we set the task of developing our own method for calculating the corresponding mathematical indicators of the accommodogram [7].

The received accommodograms were evaluated visually and quantitatively. Quantification of accomodograms, obtained on a Righton Speedy-K ver. MF-1, was completed according to the Zharov-Egorova method [8]. Held calculation of the coefficient of accommodative response (CAO), characterizing the ratio of the force of accommodative to answer in relation to the value of the accommodative stimulus, as well as the microfluctuation coefficient (HFC), which characterizes the frequency of accommodative microfluctuations of ciliary muscle fibers during their abbreviations. CAO for each step of the accommodogram was calculated by the formula CAO = AO/AC, where AO is the value accommodative response in diopters, AC is the value of accommodation modulation stimulus in diopters. Average KAO for the whole accomodograms were calculated by the formula CAOav = ∑KAO/n, where CAOav is the average value of CAO for each level accommodation stimulus;∑CAOn is the sum of the CAO of all dimension columns; n is the number of dimension columns. CMF was calculated by the formula CMF = HFCav =∑HFCn/n, where HFCn is the frequency of microfluctuations of each measurement, n is the number of dimension columns. Statistical processing of the results was carried out using Microsoft Excel 2010 with calculation Student's criterion.

III. Results

The survey showed that the accommodative functions in modern schoolchildren with myopia are somewhat different from those traditionally described in the literature. According to literature, when conducting accommodation on the device Righton Speedy-K ver. MF-1 accommodative value the response in healthy emmetropes normally does not reach a value accommodative stimulus, but lags behind it on average by 20%, amounting to 0.7–0.8. CMF normally ranges from 50 up to 62 microfluctuations per minute [5]. Obtained averages values of CAO and CMF in the groups of examined schoolchildren presented in the table (Tab. 1).

The conducted studies showed that in the group of patients with emmetropia (control), the average value of CAO corresponded to the upper limit of the average norm according to the literature (0.7–0.8) and amounted to 0,823 ± 0,140. The CMF value exceeded the norm (50–62) and amounted to 63,811 ± 1,260 microfluctuations/min. On accommodograms, most children show a high accommodative response and a predominance of high-frequency accommodative microfluctuations (orange and red diagrams). At the same time, most children have a stable accommodative response and its uniform increase with an increase in the value of the accommodative stimulus (Fig. 1).

Unusual was the accommodative response in the group of children with low myopia. The accommodograms demonstrated the instability of the accommodative response and its uneven increase, which indicates a spastic state of the muscular component of the accommodative apparatus. In the majority of these patients, during one accommodogram, both a pronounced lag in the accommodative response and an excess of the accommodative response over the magnitude of the accommodative stimulus were noted. In general, the average CAO in this group was 0,943 ± 0,270. The accommodograms also showed the predominance of high-frequency accommodative microfluctuations (CMF = 65,664 ± 1,140 microfluctuations/min) (Fig. 2).

In the group of children with moderate myopia, the accommodative response was weaker than in the group of children with low myopia and emmetropes. The value of the accommodative response in this group of patients was 60–70% of the value of the accommodative stimulus (0,658 ± 0,790). The accommodative response was characterized by uneven and insufficient growth with increasing stimulus and instability. With an increase in the accommodative stimulus to 2.0 D and higher, “gaps” appeared on the accommodograms, indicating the absence of an accommodative response to the presented stimulus. As for the frequency of accommodative microfluctuations, it also exceeded the average normal values and amounted to 63,781 ± 0,540microfluctuations/min (Fig. 3).

In patients with high myopia, the nature of the accommodative response was the same as in the group of patients with moderate myopia: CAO was 0,592 ± 0,320; CMF = 65,529 ± 0,740 microfluctuations/min. Accomodograms in children with high myopia were also characterized by a reduced accommodative response and instability at a high frequency of accommodative microfluctuations (Fig. 4).

IV. Discussion

When statistically processing the results, it was found that CAO did not differ in groups with low myopia and emmetropia, as well as in groups with moderate and high myopia. Statistically significant ($p \leq 0.05$) were the differences in CAO values between groups with emmetropia and low myopia, on the one hand, and moderate and high myopia, on the other. No statistically significant differences in the CMF index were found in all groups of the examined children. All noted an increase in the frequency of accommodative microfluctuations compared with normal values.

The study showed that, in general, the progression of myopia is accompanied by a weakening of the accommodative function, as evidenced by a decrease in the magnitude of the accommodative response in children with moderate and high myopia. However, in the pathogenesis of progressive myopia in modern schoolchildren, the spastic accommodative component is becoming increasingly important. Apparently, this is due to the high visual load caused not only by intense schoolwork, but also by the uncontrolled use of electronic devices (smartphones and tablets) by children.

V. Conclusion

In modern schoolchildren using electronic gadgets, the spastic component of accommodation is significantly expressed, which is manifested by a pathological increase in the frequency of accommodative microfluctuations and the appearance episodes of exceeding the magnitude of the accommodative response in relation to the accommodative stimulus, especially when low myopia.

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Contribution of the authors to the work

O.V. Zhukova — conceptualization and design of the study, article editing; A.V. Zolotarev — final preparation of the article; M. Abida — conceptualization and design of the study, data collection and interpretation.

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Tab. 1: Coefficient of accommodative response (CAR) and coefficient of microfluctuations (CMF) values as determined by autorefractometer with an accomodography function Righton Speedy-K ver. MF-1

Refraction	CAR	CMF (mcf/min)
Low myopia	0,943 ± 0,270	65,664 ± 1,140
Moderate myopia	0,658 ± 0,790	63,781 ± 0,540
High myopia	0,592 ± 0,320	65,529 ± 0,740
Emmetropia	0,823 ± 0,140	63,811 ± 1,260

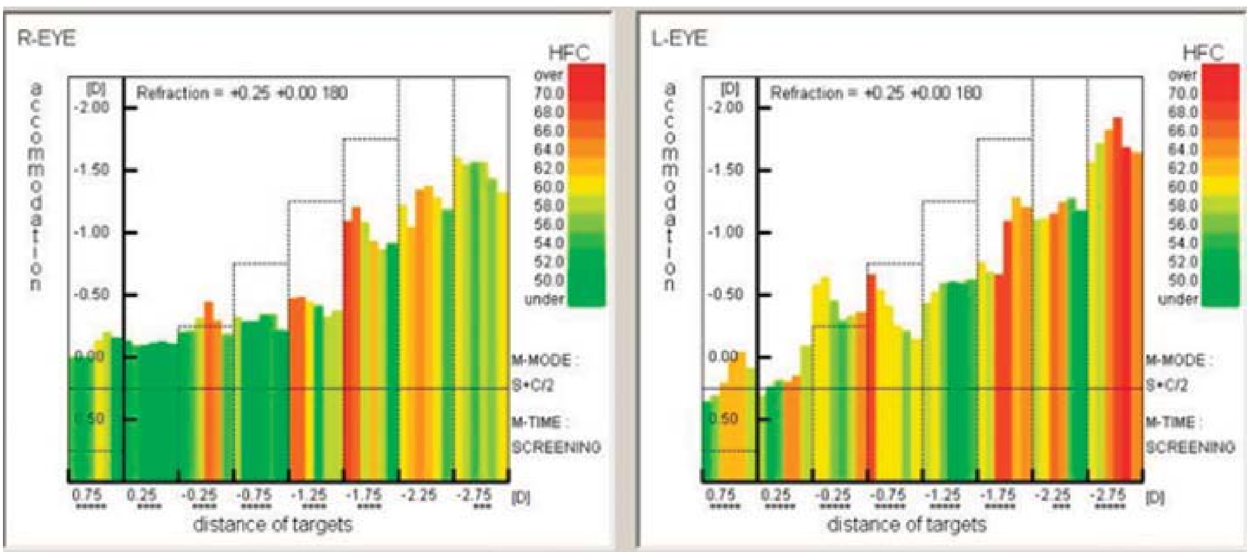

Fig. 1: Accomodogram of a child with emmetropia. Autorefractometer Righton Speedy-K ver. MF-1

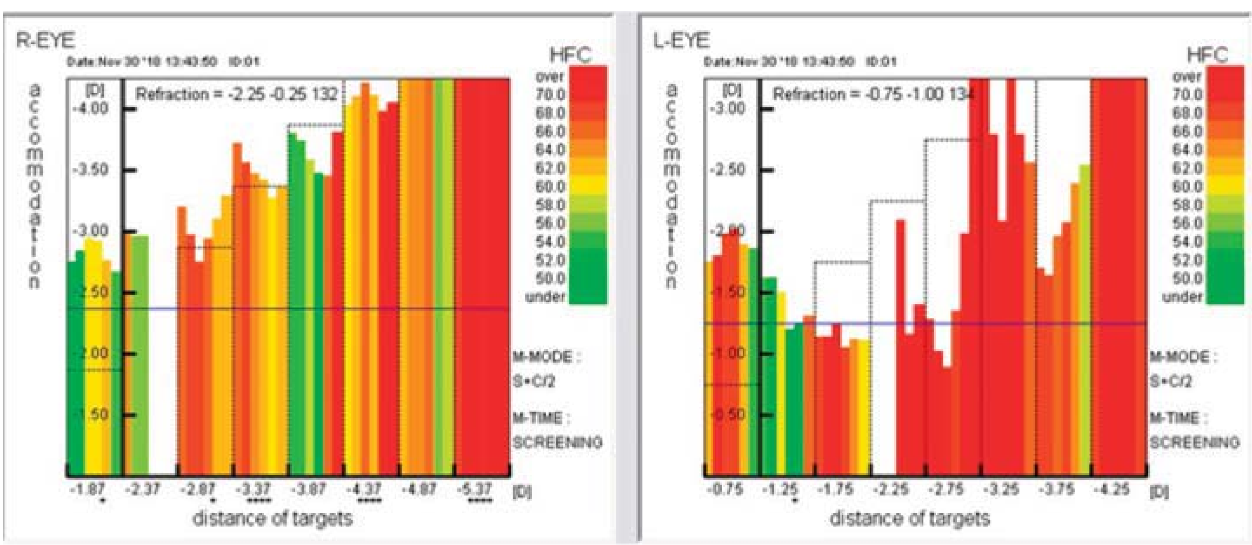

Fig. 2: Accomodogram of a child with low myopia. Autorefractometer Righton Speedy-K ver. MF-1

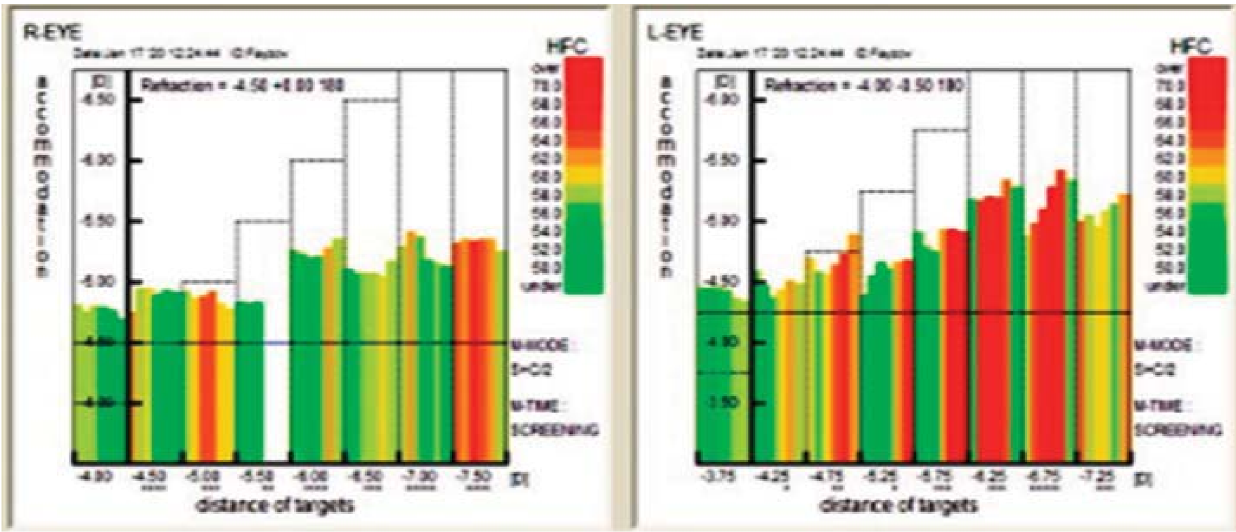

Fig. 3: Accomodogram of a child with moderate myopia. Autorefractometer Righton Speedy-K ver. MF-1

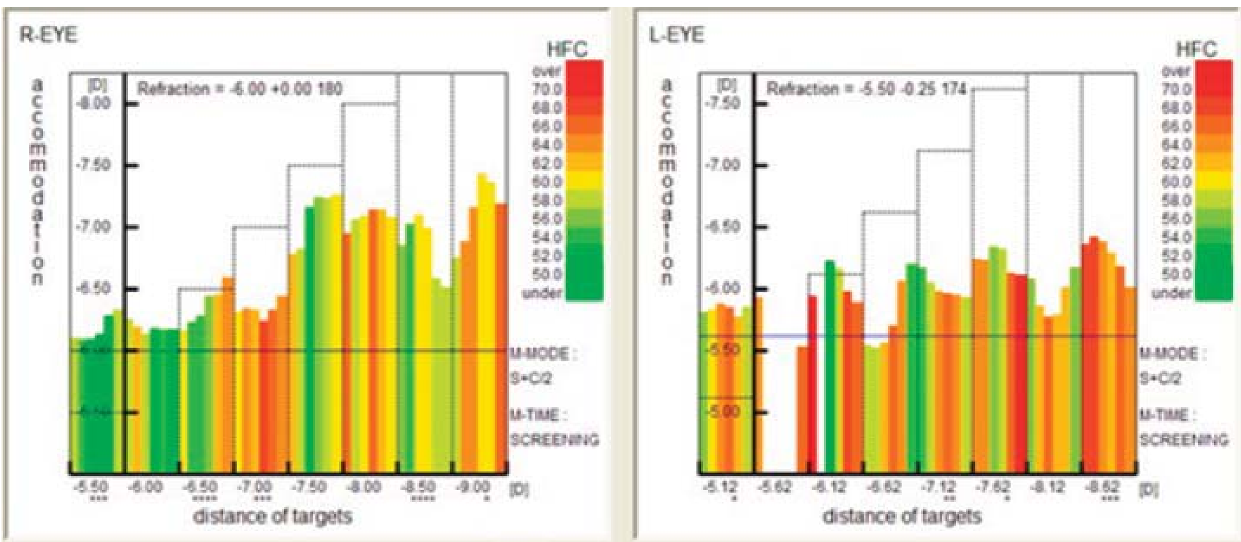

Fig. 4: Accomodogram of a child with high myopia. Autorefractometer Righton Speedy-K ver. MF-1

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