

## Age changes of parameters of the cardiovascular system in children with violation

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### ABSTRACT

**Aim:** The functional state of central hemodynamics in visually impaired girls of 7 and 8 years old, depending on the age and degree of impairment of their visual analyzer, was studied and compared with the indices of healthy children of the control group. **Materials and method:** The functional state of the cardiovascular system (CVS) was assessed by the parameters of the stroke volume (SV) of the blood, determined by tetrapolar thoracic rheoplethysmography, heart rate, minute blood volume, systolic blood pressure (SBP), diastolic BP, and mean hemodynamic BP. The adaptation potential of the CVS was studied at the beginning and at the end of the school year as a manifestation of the functional and adaptive capabilities of the circulatory system and the organism as a whole. **Results:** It was found that changes in the parameters of the CVS from 7 to 8 years in visually impaired girls do not correspond to the generally accepted ideas about its age dynamics: There are an increase in the frequency of cardiac contractions and a decrease in the SV and minute volume of blood and SBP. In this case, girls aged 7 years with a severe visual impairment (total detachment of the retina, glaucoma, and microphthalmos) experience the greatest stress in the state of hemodynamics in comparison with other visually impaired children and control girls. **Conclusion:** Thus, the period of adaptation to school in children with an abnormal visual analyzer proceeds more strenuously, and the adaptation reactions of the CVS predominate over the age-related dynamics of its parameters.

**KEY WORDS:** Adaptive potential, Hemodynamics, Visually impaired girls of 7 and 8 years old

### INTRODUCTION

According to many scientists, the most pronounced negative changes in the health of schoolchildren currently are excess body weight, a decrease in the level of physiometric parameters, and the development of visual pathology in the learning process.<sup>[1-3]</sup> The researches by Demirchoglian *et al.*<sup>[4]</sup> and Pilkevich *et al.*<sup>[5]</sup> have shown that changes in the health status of children and adolescents are closely interrelated with the function of the organ of vision, namely diseases of the nervous system, respiratory organs, and the spine, which are often combined with myopia and accommodation disorder. In this aspect, children suffering from morphofunctional impairments of their visual analyzer before entering the school, such as structural changes in the eye and refraction abnormalities, are of particular interest.

A number of studies<sup>[6]</sup> present an anatomical and physiological relationship between the visual sensory system and the vegetative functions of the organism, the relationship between visual afferentation and metabolic processes, and the state of the cardiovascular and respiratory systems. The authors believe that the light energy, directed through the eye to the hypothalamus and pituitary gland, regulates the vegetative endocrine functions of the body and exerts a general tonic effect on the central nervous system. Visual disturbances lead to the formation of secondary deviations in the physical development of children, the appearance of specific shifts in the functioning of physiological systems, and their regulation mechanisms.

Cardiovascular system (CVS) is most sensitive to exo- and endogenous influences;<sup>[7,8]</sup> it is characterized by immaturity and instability of regulatory mechanisms in childhood.<sup>[9]</sup> The restructuring of the neurodynamic processes observed in visual impairment can affect the functional and adaptive capabilities of the circulatory

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system of visually impaired schoolchildren and manifest themselves in the peculiarities of the vegetative regulation of cardiac activity.

The available literature data on the physiological characteristics of the organism of visually impaired children are usually devoted to the level of their physical development and methods of psychophysiological correction.<sup>[10,11]</sup> We did not find any information on the adaptation of the CVS of children with visual impairment to the factors of school education, subject to their age, and the severity of violations of the visual analyzer in the available literature. At the same time, the solution of the problem of social adaptation of visually impaired children and adolescents is impossible without fundamental and applied research of the circulatory system in the process of their adaptation to educational and labor activity.

The results of research aimed at studying the autonomic mechanisms of the adaptation of visually impaired schoolchildren that can serve as the basis for providing the optimal conditions for their education.

The objective of the research was to study the functional and adaptive capabilities of the CVS of visually impaired girls of 7 and 8 years old subjected to their age and the period of the school year.

## METHODS

The study was conducted on the basis of Type III and IV specialized correctional general education school and the secondary school of Kazan. The study involved visually impaired and healthy girls of 7 and 8 years old of the 1<sup>st</sup> and 2<sup>nd</sup> grades. To account for the severity of the visual analyzer abnormality, we examined separately the girls of Group A with strabismus, myopia, and operated retinal detachment and Group B with total retinal detachment, glaucoma, and microphthalmia.

To study the functional state of the CVS, the tetrapolar thoracic rheoplethysmography method was used with the rheographic complex “reo-spectrum” (Neurosoft Company, Ivanovo), which includes an analog-to-digital converter with a Pentium 4 computer. The stroke volume (SV) was calculated according to the Kubicek formula modified by Pushkar *et al.*,<sup>[12]</sup> cardiac output (CO) - as a product of SV by the heart rate (HR). Measurement of blood pressure (BP) was performed by N.S. Korotkov’s method at relative rest in a sitting position on a semiautomatic device MF-30 (Japan). Systolic BP (SBP), diastolic BP (DBP), and mean hemodynamic pressure (MHDP) were determined.<sup>[13]</sup>

Adaptation potential was calculated by Baevskii *et al.* formula,<sup>[14]</sup> which provides a preliminary quantitative

assessment of the level of adaptive capabilities of the CVS and the body as a whole without stress tests.

The statistical processing of the collected material was carried out by standard methods of variation statistics, using the Microsoft Excel Windows 2010 software package. To evaluate the authenticity of the differences, a Student’s *t*-test was used.

## RESULTS

Analyzing the age-related dynamics of the CVS of visually impaired girls, it should be noted that the HR does not change with age and ranges from  $73.71 \pm 1.34$  to  $75.62 \pm 1.40$  bpm [Figure 1a], while SV at 8 years is  $72.43 \pm 1.30$  ml, which is 9.31 ml less than in 7-year-olds ( $P < 0.05$ ) [Figure 1b]. CO indices have no significant differences, although there is a tendency to decrease from 7 to 8 years [Figure 1c]. The most significant difference is noted in the indicators of BP: The value of SBP in the 8-year-olds decreased, and the difference is 9.4 mm Hg compared with 7-year-olds ( $P < 0.05$ ). A higher level is observed for DBP -  $71.25 \pm 1.56$  mm Hg, while the 7-year-olds have the same equal to  $67.10 \pm 1.02$  mm Hg [Figure 1e]. The value of MHDP in girls of 8 years old is  $46.20 \pm 0.95$  mm Hg, and in 7-year-olds, it is much higher and is equal to  $52.40 \pm 1.42$  mm Hg ( $P < 0.05$ ).

Thus, changes in some parameters of the CVS in girls with visual impairment aged from 7 to 8 years contradict the age-related dynamics,<sup>[2]</sup> namely, the HR, which is stabilized with age, and the SV, SBP, and MHDP, which are significantly reduced. This may indicate the stress of the CVS in the period of adaptation of visually impaired girls to school, which, as is known, is accompanied by increased sympathetic influences on the heart and blood vessels<sup>[7]</sup> and is manifested in our case by a jump in CVS indices at 7 years.

A different situation is observed in healthy girls - with age, they have SBP and DBP growing. At the same time, there is a tendency for an increase in SV and CO at stable values of MHDP. These changes are quite natural and correspond to the generally accepted ideas about the age-related dynamics of the parameters of the CVS.<sup>[3,7]</sup>

A comparative analysis between visually impaired and healthy children within the age groups showed that the HR of healthy 7-year-old girls is  $78.20 \pm 1.65$  bpm, which is 3.7 bpm higher than in the impaired ones. Their SV was  $81.74 \pm 1.46$  ml, which is 13.61 ml higher than in healthy children of the same age ( $P < 0.05$ ). The schoolgirls of 8 years old had no significant differences in their SV observed, which was in the range of  $70.08 \pm 1.38$  ml up to  $72.43 \pm 1.30$  ml. CO in visually impaired girls of

7 years old was  $6.02 \pm 0.50$  l, which is 1.48 l higher than in the control group ( $P < 0.05$ ). The 8-year-olds had no differences in this indicator:  $5.83 \pm 0.42$  l and  $5.22 \pm 0.119$  l in both the groups, respectively. SBP in visually impaired girls of 7 years old was 9.53 mm Hg higher ( $P < 0.05$ ) than in healthy subjects with  $110.01 \pm 1.22$  mm Hg, and in the 8-year-olds, it was lower by 5.6 mm Hg ( $P < 0.05$ ) compared with healthy [Figure 1d]. Differences in the parameters of DBP between visually impaired and healthy children were also not revealed, the 7-year-olds had it in the range of  $67.10 \pm 1.02$  mm Hg up to  $70.20$  mm Hg, and the 8-year-olds had it in the range of  $71.25 \pm 1.56$  mm Hg– $75.44 \pm 1.00$  mm Hg. The analysis of MHDP indices revealed a different situation, namely its sharp jump in the group of girls of 7 years with visual impairment -  $52.40 \pm 1.42$  mm Hg, which is 4.7 mm Hg higher than in healthy children ( $P < 0.05$ ) [Figure 1f].

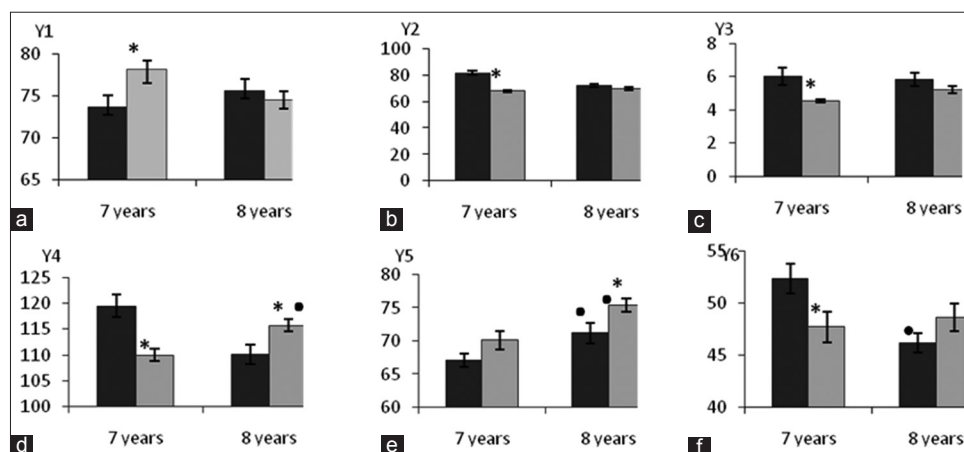
The analysis of the CVS of visually impaired children in Group A (strabismus, myopia, and retinal detachment) and Group B (total retinal detachment, glaucoma, and microphthalmos) made it possible to establish that, in 7-year-old children, the HR values in both groups differ slightly. Thus, in Group A, the HR is  $74.33 \pm 1.00$  bpm and, in Group B,  $73.32 \pm 0.94$  bpm [Figure 2a]. SV also does not differ and is in the range from  $88.40 \pm 1.60$  ml up to  $88.84 \pm 1.57$  ml. MHDP is practically at the same level and does not exceed  $6.60 \pm 0.45$  l. However, the parameters of SBP in Group B are higher and differ by 4.2 mm Hg ( $P < 0.05$ ) from children of Group A. The values of MHDP also have significant differences: In Group A, this indicator is by 31.75 mm Hg lower compared with Group B ( $P < 0.05$ ) [Figure 2b and 2c]. Thus, the girls of 7 years old of Group B have their SBP and MHDP

significantly higher than in Group A, showing a tendency for DBP to increase [Figure 2d-f].

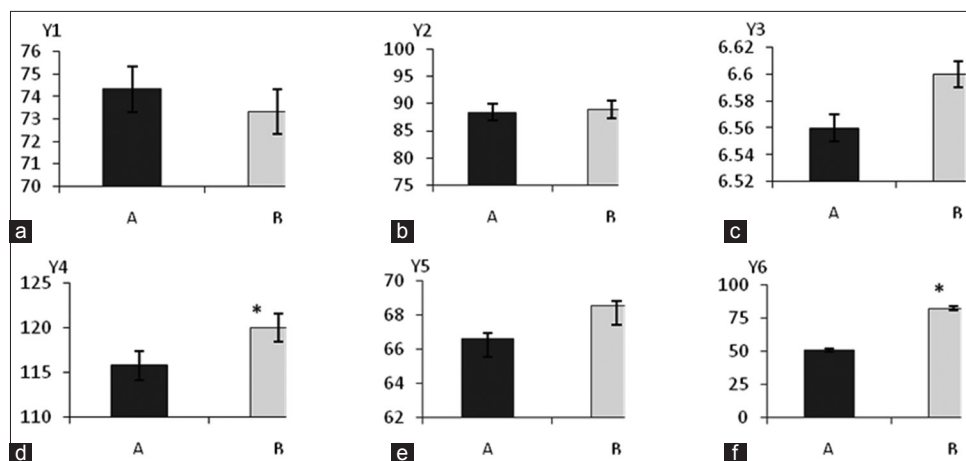
That is, 7-year-old girls with a severe degree of visual analyzer disorder experience the greatest stress in the functional state of the CVS during adaptation to the school in comparison with other visually impaired children and girls from the healthy group. At the same time, at the age of 8 years, the differences between Groups A and B are smoothed out.

To assess the adaptability of CVS and the functional state of the human body as a whole, data on the adaptive potential are used.<sup>[14,15]</sup> It was established that, at the beginning of the school year, among the visually impaired girls of 7 years old, 50% are in a state of stress adaptation, 8% have unsatisfactory adaptation and even disruption of its mechanisms, and 42% have their adaptation assessed as satisfactory. At the end of the school year, there is no unsatisfactory adaptation in sick children, but a stressed adaptation constitutes the majority - 55% [Figure 2b and 2c].

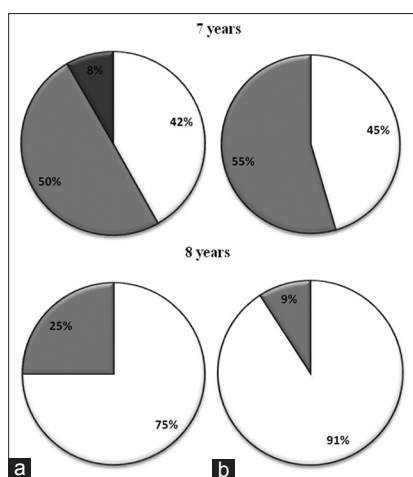
Among the 8-year-old children with visual impairment at the beginning of the school year, 25% of children are in a state of stressed adaptation, and 75% have a satisfactory adaptation [Figure 3]. At the end of the study period, the percentage of girls in a state of stressed adaptation among visually impaired children decreases up to 9%, and the state of satisfactory adaptation is 91%. Thus, the body of visually impaired children at the beginning of the school year is experiencing the greatest tension, especially children of 7 years old, who are just beginning to adapt to the school environment, unlike the control girls, whose state of adaptation is characterized as satisfactory in 100% of cases, regardless of the age and period of the school year.



**Figure 1:** The cardiovascular parameters in visually impaired and healthy girls of 7 and 8 years old. (a) Heart rate; (b) stroke volume; (c) cardiac output; (d) systolic blood pressure; (e) diastolic blood pressure; (f) mean hemodynamic pressure at the X-axis - age (years); at the Y-axis - Y1 - bpm; Y2 - ml; Y3 - l; Y4 - mm Hg; Y5 - mm Hg; Y6 - mm Hg; ■ - visually impaired girls; ▒ - healthy girls; \* - the differences are significant between the visually impaired and healthy girls:  $P < 0.05$ ; • - the differences are significant in comparison with the previous age:  $P < 0.05$



**Figure 2:** The parameters of the cardiovascular system of visually impaired girls of 7 years old with varying severity of their visual impairment. (a) Heart rate; (b) stroke volume; (c) cardiac output; (d) systolic blood pressure; (e) diastolic blood pressure; (f) mean hemodynamic pressure; at the X-axis - Group A - strabismus, myopia, and operated retinal detachment and Group B - total detachment of the retina, glaucoma, and microphthalmos; at the Y-axis - Y1 - bpm; Y2 - ml; Y3 - l; Y4 - mm Hg; Y5 - mm Hg; and Y6 - mm Hg; \* - the differences are significant between A and B at  $P < 0.05$



**Figure 3:** Percentage of different adaptation options at the beginning (a) and at the end (b) of the school year for visually impaired girls of 7 and 8 years old. □ - Satisfactory; ■ - Stressed; ■ - Unsatisfactory

## SUMMARY

1. The functional state of the CVS of visually impaired girls of 7 and 8 years old is characterized by a sharp jump in the values of SV, SBP, and MHDP at the age of 7 and their significant decrease by 8 years with stabilization of the HR, which contradicts the age-related dynamics of CVS and indicates its functional stress.
2. The visually impaired girls of 7 years old with a severe degree disorder experience the greatest stress in the functional state of their CVS - at the beginning of the academic year, they have a sharp increase in SBP and MHDP, and the value of which is significantly higher than that of other visually impaired and healthy schoolgirls.

3. The level of the adaptation potential of CVS in visually impaired children depends on the age and the period of the school year:

- a. In the group of 7-year-olds at the beginning of the academic year, the girls in the state of stressed adaptation predominate 55%, and in 8% of cases, there is an unsatisfactory adaptation and disruption of its mechanisms.
- b. Among the visually impaired 8-year-olds, the number of girls in the state of stressed adaptation decreases up to 9% from the beginning until the end of the school year; in 91% of cases, a satisfactory adaptation is recorded.
- c. In healthy children, the state of the adaptation potential of their CVS is assessed as satisfactory in 100% of cases, regardless of the age and the period of the school year.

## CONCLUSION

A comparative analysis of CVS parameters of visually impaired and healthy girls revealed differences between them, most pronounced at the age of 7 years - a significant increase in SV, CO SBP, SRS in the group of children with visual impairment compared with healthy ones. Moreover, when assessing the age-related dynamics of the CVS indicators, it should be noted that changes in girls with abnormal visual analyzer from 7 to 8 years are contrary to the generally accepted beliefs; there are an increase in HR and a decrease in SV, CO, and SBP, whereas changes in the group of healthy children are quite natural: A decrease in the HR with age, an increase in SBP, a trend toward an increase in SV and CO, and stable values of MHDP. All these allow us to conclude that the period of adaptation to school for visually impaired children is

more stressed than in the group of healthy children, and the adaptation reactions of their CVS predominate over the age-related dynamics of its indices.

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