Research Article

The influence of static load on the state of hemodynamics of schoolgirls with vision impairments

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ABSTRACT

Aim: The article describes the results of an investigation of the functional state of the cardiovascular system (CVS) of visually impaired 7–8-year-old girls, under conditions of relative rest and after a dosed local static load. Their comparative characteristics with the parameters of healthy children are also given in the work. **Materials and Method:** The following differences in the hemodynamic state of visually impaired and healthy girls, most pronounced at the age of 7, were revealed: Significant increase in the stroke and minute volume of blood, systolic and average hemodynamic blood pressure (BP) in children with visual impairments, and compared with healthy persons. **Results:** Moreover, different age-related changes in the heart rate (HR), stroke, and minute blood volume have been revealed in the studied groups from 7 to 8 years of age. Functional test in the form of a local static load (dynamometric test) shows that the reaction of the CVS of schoolgirls depends on their age and the state of the visual analyzer. The changes in hemodynamic parameters after static muscular load were not revealed in 7-year-old girls with vision impairments. However, a significant increase in the HR and BP, and a decrease in the stroke volume were defined in girls at the age of 8. **Conclusion:** Whereas in healthy 7-year-old children, the local static load causes pronounced changes in all the studied cardiovascular parameters, indicating their ability to sustain the volitional effort for a long time during static muscle tension, due to better physical fitness.

KEY WORDS: Hemodynamic, Local static load, Visually impaired girls at the age of 7 and 8

INTRODUCTION

Solution of the problem of social adaptation of visually impaired school-aged children is impossible without fundamental and applied research of the functioning of physiological systems in the process of adaptation to educational and labor activity. Complete or partial vision impairment in children leads to a lack of physical activity, limitation in the perception of the environment, activity in the cognition of the surrounding world. As a consequence, it causes the delay in general development.[1] The ongoing change in neurodynamic processes, observed in the case of visual impairment, can disrupt the formation of complex intersystem connections - visual-tactile, visual-motor, etc.[2] It can have an impact on the functional and adaptive capabilities of the physiological systems of children. This is especially evident in the process of schoolchildren's adaptation to educational activity, which has a complex influence on the mechanisms of nervous and humoral control of physiological functions of the growing organism.[3] It includes three interrelated components: Mental load, static postural tension, and dynamic physical work. As a rule, the static component predominates, and the motion activity is reduced. Cardiovascular system (CVS) is the most sensitive to external influences, and in childhood, it is characterized by immaturity and instability of regulatory mechanisms.[4] The peculiarity of hemodynamic changes, occurring in the body of children under static load, pronounced activation of the sympathetic-adrenal system and rapid-onset fatigue[5] allow to consider it as a stress factor of school education. A functional test in the form of a dosed local static load causes peripheral vasoconstriction and allows to assess the level of compensatory-adaptive capacities of hemodynamics. However, we not found any information on the reactions of the CVS of visually impaired children to the static muscular load, taking into account the age and degree of disorder of visual analyzer, in the available literature. At the same time, the results of

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such studies can become a scientific basis for the organization of the learning process for visually impaired schoolchildren, which will optimally combine the static and dynamic components of learning activity. All of the above has determined the relevance and purpose of our research - the study of the age-specific features of the reactions of urgent adaptation of the CVS in visually impaired schoolchildren, at the age of 7 and 8, in response to a dosed local static load.

METHODS

The study was conducted on the basis of Specialized Remedial School of the III and IV Types and the Secondary General School of Kazan. The study involved visually impaired and healthy girls, 7–8 years old, the first and the second graders. To take into account the degree of severity of visual analyzer pathology, the girls of the Group A (having strabismus, myopia, and operated detachment of retina) and the Group B (having total detachment of retina, glaucoma, and microphthalmia) were studied separately.

To study the functional state of the CVS, the method of tetra polar thoracic rheoplethysmography was applied, using the rheographic complex "Reo-Spectrum" (OAO "Neurosoft", Ivanovo). It includes the analog-to-digital converter in conjunction with computer Pentium-4. The stroke volume (SV) was calculated using the formula of Kubicek in the modification of Pushkar *et al*.[6] The minute blood volume (MBV) was estimated as a product of SV by the heart rate (HR). Measurement of blood pressure (BP) was performed using the method of N.S. Korotkov, in a state of relative rest, in a sitting position, and in a semi-automatic device MF-30 (Japan). Systolic BP (SBP), diastolic BP (DBP), and average hemodynamic BP (AHBP) were determined.[7]

The test with isometric exercise was carried out in the sitting position of the test person, by way of tighten of a manual dynamometer with the left hand, with force equal to 50% of the maximum voluntary effort, during 1 min. The average value after three attempts was taken as the index of maximum voluntary effort. The parameters of hemodynamics were recorded before the load and at the 1st min of the recovery period.

Statistical processing of the collected material was carried out using the standard methods of variation statistics, applying the software package of Microsoft Excel Windows. *t*-test, based on Student's t-criteria, was used to evaluate the reliability of differences.

RESULTS

Comparative analysis of indicators of children with visual impairments and healthy children within the age groups shows the following results: The HR of healthy 7-year-old girls is 78.20 ± 1.65 beats per minute, i.e., 3.7 bpm more than in children with disorders. Their SV values are 81.74 ± 1.46 ml, i.e., 13.61 ml more than in healthy children of the same age ($P < 0.05$). There are no significant differences in SV values of 8-year-old girls, they are in the range from 70.08 ± 1.38 ml to 72.43 ± 1.30 ml. MBV in visually impaired 7-year-old girls is 6.02 ± 0.50 l, i.e., 1.48 l more than in the healthy group ($P < 0.05$). There are also no significant differences in MBV values of 8-year-old girls: 5.83 ± 0.42 l and 5.22 ± 0.119 l in the first and the second group, respectively. SBP in 7-year-old girls with vision impairment is 9.53 mmHg higher ($P < 0.05$) than in healthy children, who have the value of this parameter 110.01 ± 1.22 mmHg. There are no differences in DBP between visually impaired and healthy children: In 7-year-old girls, it is within the range from 67.10 ± 1.02 mmHg to 70.20 mmHg, and in 8-year-old girls, it is in the range from 71.25 ± 1.56 mmHg to 75.44 ± 1.00 mmHg. The analysis of AHBP revealed other picture, namely the sharp change in the value of this parameter in the group of 7-year-old girls with visual impairment - 52.40 ± 1.42 mmHg that was 4.7 mmHg more than in the group of healthy children ($P < 0.05$).

It was also defined that in girls with visual impairment, the changes in some parameters of the CVS from 7 to 8 years of age contradicted their age dynamics.[8] Namely, the HR stabilizes with age; the values of SV, SBP, and AHB produce significantly. This may indicate the tension of the CVS during the adaptation of visually impaired girls to school. As it is known, this is accompanied by an increase in sympathetic influences on the heart and blood vessels[9] and is manifested, in our case, by the change in the parameters of the CVS at the age of 7. Other picture is observed among healthy girls - their SBP and DBP increase with age. At the same time, there is a tendency for an increase in SV and MBV, at stable values of AHBP. These changes are quite natural and correspond to the generally accepted ideas about the age dynamics of hemodynamic parameters.[8]

Functional capabilities of the CVS were studied by us by the nature of change of its indicators in response to a dosed local static load. The analysis shows the following results of 7-year-old girls with vision impairment, after the load the HR increases only by 0.4 bpm, SV - by 0.61 ml, and MBV - by 0.08 l, the value of SBP also remains practically unchanged (at rest it is 119.54 ± 2.10 mmHg, and after a load it is 122.73 ± 1.30 mmHg). The difference in the values of DBP before and after the load is 0.91 mmHg. AHBP before the load is 52.40 ± 1.42 mmHg, and after the load is 51.54 ± 1.64 mmHg, i.e., also statistically insignificant.

Thus, in visually impaired 7-year-old girls, the changes in the parameters of the CVS after the local static load are practically absent. This may indicate the unformedness of mechanisms of urgent adaptation of the CVS to static muscular loads [Table 1]. We came to the conclusion that visually impaired girls cannot sustain the volitional effort in case of isometric muscle tension, that may indicate a low level of their physical development and asthenia.

An 8-year-old girls with vision impairments have other values of indicators after the static load: The HR increases by 4.98 bpm ($P < 0.05$), SV value reduces by 8.13 ml ($P < 0.05$), and MBV remains practically unchanged and range from 5.26 ± 0.30 l and to 5.51 ± 0.13 l. SBP of visually impaired girls rises by 8.67 mmHg, in comparison with the rest, where it does not exceed 110.14 ± 1.86 mmHg ($P < 0.05$). DBP value increases by 7.15 mmHg, whereas before the load it is 71.25 ± 1.56 mmHg. AHBP also increases by 5.7 mmHg, then at rest ($P < 0.05$). That is, visually impaired 8-year-old girls have more significant changes in the parameters of the CVS after the local static load, compared to 7-year-old children [Table 1]. There is a significant increase in the HR and SBP in the background of a decrease in SV. However, a sharp increase of DBP and especially AHBP may indicate that the adaptation of the CVS to the local static loads in girls with vision disorders is formed by the sympathicotonic type that, according to the scientists, has an adverse effect on the state of vascular tone.[10]

Thus, the reaction of the CVS of visually impaired schoolgirls at the age of 7 and 8, to the local static load has age differences. In 7-year-old girls with the disorder of visual analyzer, the indicators have insignificant differences, and in 8-year-old children, the values of HR, SBP, DBP, and AHBP increase that is statistically confirmed. It should also be noted that the value of SV significantly reduces after the load in 8-year-old visually impaired schoolgirls.

The results of studies of healthy 7-year-old children show that their HR before the load is 74.60 ± 0.85 bpm. After the functional test, it increases by 4.41 beats per minute ($P < 0.05$) [Figure 1]. The value of SV at rest does not exceed 68.13 ± 1.08 ml, and after a load, it is 75.23 ± 1.56 ml, i.e., it increases by 7.1 ml ($P < 0.05$). MBV of 7-year-old girls after the load also significantly increases up to 5.94 ± 0.13 l ($P < 0.05$). Changes in the values of SBP are similar: 110.01 ± 1.22 mmHg and 120.20 ± 1.65 mmHg before and after the load, respectively, i.e., the difference is 10.19 mmHg ($P < 0.05$).

At the same time, the value of DBP before the load does not exceed 70.20 ± 1.38 mmHg. After the load,

Table 1: Reaction of the cardiovascular system to a local static load in visually impaired 7–8-years-old girls

Age	Parameters											
	Heart rate beats per minute		Stroke volume, ml		Minute blood volume, l		Systolic blood pressure, mmHg		Diastolic blood pressure, mmHg		Average hemodynamic blood pressure, mmHg	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
7	73.71±1.34	74.11±1.30	81.74±1.46	82.35±0.95	6.02±0.50	6.10±0.55	119.54±2.10	122.73±1.30	67.10±1.02	68.01±1.00	52.40±1.42	51.54±1.64
8	75.62±1.40	*80.60±1.30	72.43±1.30	*64.30±1.52	5.26±0.30	5.51±0.13	110.14±1.86	*118.81±1.00	71.25±1.56	*78.40±0.92	44.20±1.66	*49.90±1.20

*The differences are significant in comparison with the values before and after static load: $P<0.05$

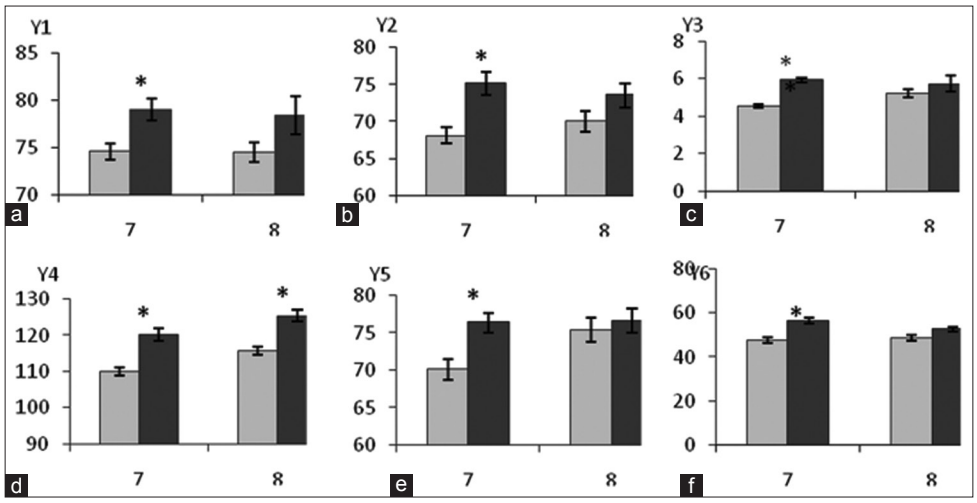

Figure 1: Changes in the parameters of the cardiovascular system in response to the local static load in healthy girls at the age of 7 and 8. Remark: (a) Heart rate; (b) stroke volume; (c) minute blood volume; (d) systolic blood pressure; (e) diastolic blood pressure; and (f) average hemodynamic blood pressure; Horizontally: Age (years). Vertically: Y1 - bpm; Y2 - ml, Y3 - l; Y4 - mmHg, Y5 - mmHg; Y6 - mmHg; ϒ - before the load; ■ - after the load; * - the differences are significant in comparison with the values before and after the static load, $P < 0.05$

it increases to 76.40 ± 1.34 mmHg. AHBP in healthy 7-year-old girls is 47.70 ± 1.50 mmHg at rest, and after the load it rises by 8.7 mmHg ($P < 0.05$).

The analysis of the response of the CVS of healthy 8-year-old children to the dosed static load shows that the value of HR before the load is 74.50 ± 1.00 beats per minute, and after the load it is 78.43 ± 2.00 beats per minute, i.e., it increases by 3.93 bpm [Figure 1]. The value of SV at rest does not exceed 70.08 ± 1.38 ml, and during the recovery period it is 73.60 ± 1.62 ml, i.e., it increases by 3.52 ml. MBV in 8-year-old girls before the load is 5.22 ± 0.119 l, after the load is 5.73 ± 0.42 l; the difference is 0.51 l, i.e., statistically unreliable. Significant difference was found in the values of SBP: Before the load, it was equal to 115.74 ± 1.20 mmHg, and after the load - 125.32 ± 1.60, the difference between values was 9.58 mmHg ($P < 0.05$).

Thus, in healthy 7-year-old girls, compared with visually impaired, local static load causes significant changes in all studied parameters of the CVS, indicating the ability of healthy schoolgirls to sustain a static muscular effort for a long time, probably due to their better physical fitness. At the age of 8, the response of the CVS is less pronounced; there is a tendency to increase in all parameters with a reliable raise of SBP. It is shown that the propensity to hypertensive reactions is a distinctive age-specific feature of CVS responses to the local static load in all 7- and 8-year-old girls, regardless of the state of the visual analyzer, except for 7-year-old children with vision impairments. This is confirmed by a significant increase in such indicators as SV, DBP, and AHBP.[10]

Discussing the results obtained, we can state that the reaction of the CVS of a healthy child's organism to a static muscular load is peculiar. The analysis of the research results shows that the age-related dynamics of the mean group parameters of CVS reaction is the same in girls. After the dosed physical load, BP of 7–8-year-old children increases significantly less than in adults. This is probably because of a weak development of the heart muscle, a small volume of cardiac output, and a wider lumen of blood vessels, relative to the size of the heart. Delivery of oxygen to the working muscles in 7–8-year-old children is provided, mainly, due to the increased blood flow. In adults, the increased utilization of blood oxygen plays a valuable role in this process.[11,12]

SUMMARY

1. Comparative analysis of the functional state of the CVS of visually impaired and healthy girls allowed to identify the differences, which were the most pronounced at the age of 7: The relative increase in the values of SV and MBV, as well as SBP and AHBP in children with visual impairment, compared to healthy girls.
2. The response of the CVS to the local static load in 7–8-year-old children depends on the age and state of visual analyzer:
   a. In visually impaired 7-year-old schoolgirls there are no changes in hemodynamic parameters after the dosed load.
   b. Significant increase in the HR, SBP, AHBP, and DBP, on the background of a decrease in SV was revealed in the visually impaired 8-year-old girls.
   c. In healthy 7-year-old schoolgirls, in contrary

to the visually impaired, the local static load causes pronounced changes in all the studied parameters (HR, SV, MBV, and BP). This is probably connected with the ability of healthy girls to sustain the volitional effort for a long time in case of isometric muscle tension.

3. Regardless of the age and degree of disorder of the visual analyzer, 7–8-year-old girls have the hypertensive character of the reaction of the CVS to a local static load, accompanied by significant increase in SV, DBP, and AHBP.

CONCLUSION

The conducted study showed that the response of hemodynamics to the local static load in younger schoolchildren depends on the age and the state of the visual analyzer. In 7-year-old girls with visual impairment, the response of the CVS to static muscular load is moderate or absent, whereas, at the age of 8, significant changes in all studied parameters are observed. In healthy 7-year-old children, local isometric load causes significant changes in the state of the CVS, indicating their ability to sustain volitional effort for a long time during static muscle tension. It has also been established that the tendency to hypertensive vascular reactions is a distinctive age-specific feature of CVS responses to the dosed static load in all 7- and 8-year-old girls, regardless of the state of the visual analyzer. This is confirmed by a significant increase in such indicators as SV, DBP, and AHBP.

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