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CHARACTERISTICS OF THE FUNCTIONAL CONDITION OF THE CARDIOVASCULAR SYSTEM OF CHILDREN 11, 12 YEARS OLD

ABSTRACT:

The purpose of the work is to determine the level of functional state of the cardiovascular system of children aged 11.12 years. **Materials and methods.** The study of functional indicators of the cardiovascular system in children (128) of two age groups (11 and 12 years). Physiometric parameters that characterize the functional state of the cardiovascular system, blood flow organs - heart rate (heart rate, beats per minute), systolic (ATC, millimeters of mercury), diastolic (ATD, millimeters of mercury) were measured directly. The Robinson's index was used as an indicator of the functionality of the cardiovascular system. Determination of the adaptive potential of the cardiovascular system was used as an integral indicator of the level of physical condition of children. **Research results.** The percentage of those who are dominated by the sympathetic nervous system and there is a shift towards sympathetic regulation in 12-year-old children is 13.3% and 16.7, respectively. Of the total number of subjects in 11-year subjects can be found such a large number (about 35.5% and 8.8% of students with sympathetic regulation and strong dominance of the sympathetic system), which can further lead to reduced functional capacity and the body. Indicators of the state of regulation of the cardiovascular system of children 11 and 12 years are at a level "below average". Comparing the percentage of schoolchildren in terms of adaptation capacity in groups 11 and 12 years, it was found that the largest number in the percentage of children with "unsatisfactory adaptation", which corresponds to unsatisfactory adaptation to environmental conditions while reducing functionality, in the group of 12 years (76, 67%) The number of children with unsatisfactory adaptation among 11-year-olds is 44.32% less. **Conclusions.** The results of the calculation of the Robinson index showed that in both groups of children 11 and 12 years of age the functional capabilities of the cardiovascular system are at a level "below average", and in children 12 years of age they are slightly lower. The average indicators of adaptation potential of the first group of 11-year-old children indicate the stress of adaptation.

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In the second group of 12 years, the level of adaptive capacity decreases sharply, it corresponds to unsatisfactory adaptation. The obtained research results are also a confirmation of the negative dynamics of the functional state, reserves and regulation of the cardiovascular system in the studied children. In order to improve the functional state of the respiratory system of schoolchildren, it is necessary to reduce the impact of hypodynamics, the impact of health technology, health programs.

INTRODUCTION.

Control, continuous assessment and monitoring of the current and previous state of individual and group health is important for the use of effective health technologies.

Early detection of deviations in the direction of reducing the functionality of the cardiovascular system plays a role in preventing the occurrence of pathologies of the cardiovascular system.

Now the level of stress is outstripping both those who are in the war zone and those who are forced to move to another area, the country. Loss of loved ones, constant fear of air strikes and shelling, loss of normal living conditions, loss of a roof over your head, lack of basic things such as water and food, warmth and the ability to sleep. People are experiencing the horrors of an unexpected and terrible war with the aggressor country to varying degrees. Stress and environmental factors have become the main causes of poor health (injuries, injuries).

The main component of health is lifestyle.

Monitoring the condition of the cardiovascular system, including children, makes it possible to use health-preserving technologies that increase the body's resistance to environmental factors.

In recent years, before the COVID19 pandemic, there has been a negative trend in the growth of cardiovascular disease in schoolchildren. This was primarily due to information overload, stressful situations, modernization, informatization, digitalization, hypodynamics, the trend of "fast food", as well as the spread of bad habits.

These conditions lead to an increase in the load on the cardiovascular system, which provides organs and tissues with oxygen and energy material.

After the COVID19 pandemic, the level of stress and hypodynamics only increased. The level of motor activity, respectively, decreased sharply. Learning has moved into the realm of online learning. The amount of time children began to spend sitting in front of computer screens, phones or tablets has only



increased, because distance learning involves working on the Internet platforms Google Class, Zoom, search engines and outside classroom hours, to perform independent additional tasks. Thus, we received a sharp decrease in physical activity among children.

Decreased physical activity is an important factor in lagging behind in physical development, memory impairment, decreased resistance and endurance. It is known that optimal motor activity helps maintain and strengthen the health of children [1, 2, 3]

In the structure of integrated health indicators, the "contribution" of physical activity is 13.9 - 14.3%.

The issue of optimizing the level of motor activity of the population of different age groups has been solved for decades by scientists of social sciences, preventive medicine, genetics, sports medicine, pedagogical sciences.

Such "weak links" as insufficient physical activity at school, high duration of sedentary behavior and lack of active forms of leisure do not allow middle school children to reach the optimal level of physical activity [4].

The topical issue of general and age physiology is the study of health, functional state of the cardiovascular system, the problem of timely and objective assessment of current adaptive capabilities of children of different ages, the allocation of conditionally critical periods of significant reduction of such opportunities, the use of health and preventive measures aimed at improving the adaptation of the child's body, maintaining and developing health. [5, 6, 7, 8, 9, 10, 11, 12].

The purpose of our research is to assess the functional state of the cardiovascular system and adaptive capacity in children 11, 12 years. The study involves determining the characteristics of the cardiovascular system by calculating the Robinson index (IR), its adaptive capacity (AP) and the level of functional state of the circulatory system.

At present, studies of the state of health and the functional state of the cardiovascular system are relevant

There is an active study of factors that negatively affect and are the triggers of diseases: psycho-emotional stress, stress, malnutrition, high cholesterol, lack of motor and physical activity [13, 14, 15].

MAIN PART.

The study involved 128 children aged 11, 12 years, who came on vacation to the children's camp "Green Hill" Kharkiv region, Zmiiv district. The study was

conducted in August 2019, in accordance with the ethical principles of medical research conducted on humans.

Two groups of 11 and 12 years old were formed, including 40 girls and 28 11-year-old boys and 30 12-year-old girls and 30 boys.

Registration and testing of functional indicators of the cardiovascular system of the subjects was performed according to the generally accepted method, using standard devices. To characterize the results we used the method of indices (Robinson index IR, Kettle index, index of the level of functional state of blood circulation (LFS)) and gave an integrated assessment of adaptive capacity according to the method of GL Apanasenko (1987) [15].

To assess the functional state of the organism used anthropometric indicators, indicators of hemodynamics according to existing methods [12, 16]. We recorded the following indicators: body length (BL, cm) and body weight (BW, kg), heart rate (heart rate, beats / min), systolic (SP, mm Hg), diastolic (DP, mm Hg), Kettle's index, Robinson's index (IR), index of a level of a functional state of blood circulation (LFS), adaptive potential (AP). Robinson Index (IR) - characterizes the state of regulation of the cardiovascular system. The method of standards with a key was used to interpret his data [16].

Statistical processing of the obtained data was performed using the programs "Statistica 6.0 for Windows" and "Microsoft Excel". The arithmetic mean (M) and the arithmetic mean error (+m), the significance of the difference in indicators according to the Student's t-test were determined.

Analysis of the results of measuring anthropometric indicators in children 11 years old showed that they have an average average height (147.8 ± 2.25 cm). There is an above average body weight (38.5 ± 4.6 kg). Indicators of physical development of children 12 years old were characterized by the average height and weight (respectively 154.1 ± 5.8 cm, 41.6 ± 3.8 kg). Analysis of the results characterizing the harmony of body weight and height of children in age and comparing them with the evaluation scale showed that the absolute values of the Kettle index in both groups are on average as in 11-year-old children (261.2 ± 15.21 conventional units). conventional units) and in the group of 12-year-old children (268.8 ± 9.92 conventional units). This indicates that in boys and girls 11 and 12 years of age the physique is harmonious, physical development is harmonious.

A comparison of similar data in the gender aspect, found no differences in the Kettle index in girls and boys 11 years (girls 264.4 ± 12.21 conventional units, boys 264.3 ± 9.42 conventional units) and 12 years (girls 264.9 ± 12.92 conventional units, boys 272.7 ± 21.14 conventional units) ($p > 0.05$) (table 1).



Table 1

Indicators of body weight, height and Kettle index of children 11-12 years (M + m)

Group (n)	Height, cm	Body weight, kg	Kettle Index
Girls 11 years old (48)	149±18,4	38,6±7,2	264,4±12,21
Boys 11 years old (20)	146,0 ± 7,5	38,4 ± 10,5	264,3 ± 9,42
Girls 12 years old (30)	154,5±6,1	41,1±9,1	264,9±12,92
Boys 12 years old (30)	153,7±9,4	42,1±8,7	272,7±21,14

To determine the state of the cardiovascular system, heart rate, systolic and diastolic blood pressure were measured. The results of determining the functionality of the cardiovascular system of the subjects are shown in table 2.

Table 2

Indicators of the functional capabilities of the cardiovascular system of children 11-12 years (M + m)

Group (n)	Heart rate, beats per minute	SP, mm Hg	DP, mm Hg
11 years (68)	80,7±5,22	109,4±2,34	71,2±2,56
12 years (60)	81,3±3,24	112,9±6,22	71,4±2,95

In the study of heart rate, it was found that the absolute values of heart rate among the two groups in children 11 years of age were insignificantly ($p > 0.05$) lower and amounted to 80.7 ± 5.22 beats per minute. The heart rate, as an absolute indicator of hemodynamics, in the group of 12-year-old children was correspondingly higher - 81.3 ± 3.24 beats per minute. Comparing with the age norms of heart rate, it was found that in the first age group, 50 percent of children had a heart rate above the age norm. An individual analysis of heart rate indicators showed that in the second group, the percentage of children with a higher than normal rate was 16.67 more (73.33% of girls and 60% of boys aged 12). And in the first group of 11 years the percentage with a heart rate above the norm is lower - 45% of girls and 57.14% of boys 11 years.

The data presented in table 2 showed that in the group of 11-year-old systolic blood pressure was at the level of $SP\ 109.4 \pm 2.34$ mm Hg. In the group of 12-year-old children systolic blood pressure was insignificantly higher ($p > 0.05$) than in 11-year-olds and was higher than normal ($SP\ 112.9 \pm 6.22$ mm Hg).

Individual analysis of hemodynamic indicators of systolic blood pressure showed that in 90% of 12-year-olds it is above normal and only 10% in normal. There were slightly fewer children in the first group compared to the second group with an above-normal SP (70.60%).

The situation is the same with diastolic blood pressure: 11-year-old schoolchildren - DP = 71.2 ± 2.56 mm Hg, then there is almost no increase in 12-year-old students - DP = 71.4 ± 2 , 95 mm Hg. Individual age analysis of diastolic blood pressure showed that almost 91% of children aged 11 years are above normal, as well as almost 97% of surveyed children aged 12 years.

Compared with the age norms for boys and girls, it is shown that among 12-year-old girls a higher percentage of those with systolic blood pressure is higher than normal. With age, the number of children with high systolic blood pressure increases (93.33% of girls and 86.67% of boys 12 years) (Table 3).

Individual analysis of hemodynamic indicators of diastolic blood pressure showed that in most 11-year-old girls (95%) and 85.71% of boys it is above normal and in 93.33% of 12-year-old girls and 100% of boys (Table 4).

Table 3

Gender systolic blood pressure

			11 years	12 years
Above the norm	Girls	Number	28	28
		%	70	93,33
	Guys	Number	20	26
		%	71,43	86,67
Norm	Girls	Number	12	2
		%	30	6,66
	Guys	Number	8	4
		%	28,57	13,33

Thus, it was found that the rate of SP in group II is above normal and the average value of SP in group I is also above normal. Indicators of diastolic blood pressure DP in group II are higher than normal, as in group I.

Table 4

Diastolic blood pressure by gender distribution

			11 years	12 years
Above the norm	Girls	Number	38	28
		%	95	93,33
	Guys	Number	24	30
		%	85,71	100

Table 4 (continued)

			11 years	12 years
Norm	Girls	Number	2	2
		%	5	6,66
	Guys	Number	4	0
		%	14,29	0

One of the indicators of the functional state of the cardiovascular systems in the state of relative rest is the Robinson Index (IR):

$$IR = \text{heart rate} * SP / 100, \quad (1)$$

Where heart rate - pulse at rest, beats per minute; SP - systolic blood pressure, mm Hg. It is noted that the lower the IR, the higher the maximum aerobic capacity and, consequently, the level of physical health of the individual.

In the study of the Robinson index, it was found that the absolute values of the indicator in children 11 years are lower and amounted to 88.4 ± 4.1 conventional units. In the group of children 12 years, the value was correspondingly significantly higher ($p > 0.05$) - 3.5 conventional units (91.9 ± 3.8 conventional units). It was found that in the first group of 11 years, comparing the Robinson index with the rating scale, the indicators correspond to a score of 2 points. It can be noted that the indicators of the state of regulation of the cardiovascular system of children 11 years old are at a level "below average". The same goes for the Robinson index of 12-year-olds.

The results of determining the percentage of schoolchildren by Robinson index are shown in Table 5. It is shown that children with a harmonious ratio between parasympathetic and sympathetic levels of regulation, the average level of physical health in the 12-year group - 60%. However, there are no children with a high level, dominated by the parasympathetic autonomic nervous system. Comparing the percentage of schoolchildren according to the levels of the Robinson index, it is shown that the number of children with a high level of the Robinson index in the group of 11 years is, but insignificant - 14.7%. These children are characterized by maximum aerobic capacity of the body, which corresponds to a high level of physical health. Almost 9% of 11-year-old children with above-average physical health are characterized by parasympathetic regulation of heart rate. Among 12-year-old children with maximum aerobic capacity were not detected.

At the same time, sympathetic regulation of the heart and the dominance

of sympathetic regulation are characteristic of 44.1% of 11-year-old children, which is 14.1% more than 12-year-old children.

Table 5

Percentage distribution of students by levels of the Robinson index

Age	High	Above average	Average	Below average	Low
	Number, %	Number, %	Number, %	Number, %	Number, %
11 years	14.7	8.8	32.4	35.3	8.8
12 years	0	10	60	16.7	13.3

In general, in the sample of children aged 11-12 tested during the summer holidays, the largest number of those with an average level of regulation of the cardiovascular system - 45.3%. It should be noted 17.2% of students with parasympathetic regulation and strong dominance of the parasympathetic system.

To determine the adaptive potential, the obtained indicators of resting heart rate, diastolic blood pressure (DP), systolic blood pressure (SP), age, weight and height were used. The adaptive potential of AP of the cardiovascular system of children aged 11 and 12 years was determined using the formula empirically, using the formula proposed by RM Baevsky [8, 17].

Table 6

Percentage distribution of students by indicators of adaptive potential

	Satisfactory adaptation		Stress adaptation		Unsatisfactory adaptation		Failure of adaptation	
	Number, %		Number, %		Number, %		Number, %	
11 years	0	0	46	67,65	22	32,35	0	0
12 years	0	0	14	23,33	46	76,67	0	0

Comparing the percentage of schoolchildren in terms of adaptation capacity in groups 11 and 12 years, it was found that the largest number in the percentage of children with "unsatisfactory adaptation", which corresponds to unsatisfactory adaptation to environmental conditions while reducing functionality, in the group of 12 years (76, 67%) (table 6). The number of children with unsatisfactory adaptation among 11-year-olds is 44.32% less. Not

found among both groups of subjects who have a satisfactory adaptation. Satisfactory adaptation of the organism to environmental conditions is observed at high or sufficient functional capabilities of the organism. Therefore, according to the results of the study, no such age groups were found among the surveyed data. The number of 11-year-old children with adaptation stress is 44.32% higher than in the 12-year-old group (23.33%).

According to the results of research, the average adaptive potential of group I children is 1.9 ± 0.2 conventional units. This indicates the stress of adaptation, the stress of adaptation mechanisms, in which sufficient functionality is provided through the mobilization of functional reserves. Determining the average indicators of adaptation potential, it was found that in the second group the level of adaptation capabilities is significantly worse (4.5 ± 0.4 conventional units) ($p < 0.001$) and corresponds to unsatisfactory adaptation. Thus, with age, the adaptive capacity of 12-year-old students deteriorates.

Comparing the percentage of students by levels of functional status of the circulatory system in groups, it is clear that the highest percentage of children in both groups with a level of functional status of the circulatory system below average (Drawing 1). In the group of 12-year-old schoolchildren, their number is 11.1% more and is 70%. At the same time, there is also a smaller number of children in this group with an indicator of the level of functional state of the circulatory system above average (3.3%). And in the group of 11-year-old children the number of those who have a level of functional state of the circulatory system above average, more than 5.5%. It is noted that in both groups there are no examined with a high level of functional state of the circulatory system.

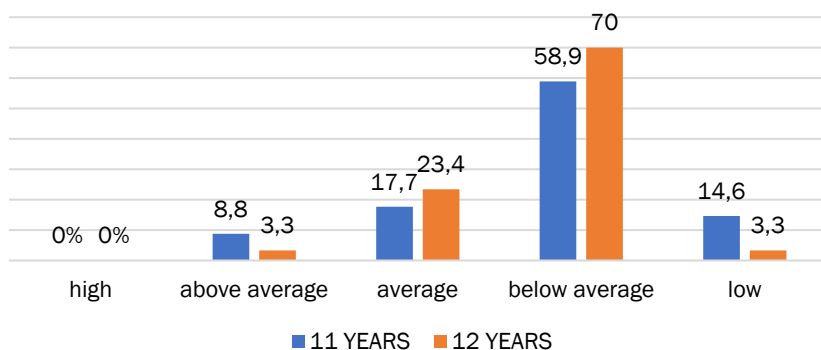


Fig. 1. The level of functional state of the circulatory system in percentage

The results of the percentage analysis are presented in Table 7. Comparing the percentage of girls and boys by levels of functional state of the circulatory system, it was found that 55% of 11-year-old girls have below average level of functional state of the circulatory system, and another 20% - low. At the same time there are no girls with high level of functional status. In the group of 12-year-old girls, the largest share was also below the average level of functional status (60%) and there were no girls with a high level of functional status.

The picture is similar in the percentage analysis of results in boys: 64.29% of 11-year-old boys have a lower level of functional state of the circulatory system, 7.14% have a low level, there are no boys with a high level of functional status. In the group of 12-year-old boys also have the largest share below the average level of functional status (80%), there is no one with a high level of functional status, while there are no boys with low level of functional status of the circulatory system.

Table 7

Percentage distribution of schoolchildren by indicators of the level of functional state of the circulatory system in percentage

			11 years	12 years
High level	Girls	Number	0	0
		%	0	0
	Guys	Number	0	0
		%	0	0
Above average level	Girls	Number	6	2
		%	15	6,67
	Guys	Number	0	0
		%	0	0
Average	Girls	Number	4	8
		%	10	26,67
	Guys	Number	8	6
		%	28,57	20
Below average level	Girls	Number	22	18
		%	55	60
	Guys	Number	18	24
		%	64,29	80
Low level	Girls	Number	8	2
		%	20	6,67
	Guys	Number	2	0
		%	7,14	0



The level of functional state of the circulatory system in the group of 12-year-old schoolchildren has an indicator - 0.507 ± 0.009 conventional units, and in the first group 0.012 more - 0.519 ± 0.014 conventional units.

Discussing the results of the study, we can state in the group of 12-year-olds a larger share (66.67%) of those who had a heart rate above normal. Thus, the results of studies of hemodynamic heart rate showed that in the group of 12-year-old schoolchildren it is insignificantly worse than in 11-year-old children. The reason for the fact that among 12-year-old children the percentage of girls with a heart rate above normal increased to 73.33% is, in our opinion, a critical period of growth and intensification of puberty, hormonal effects on the cardiovascular system.

The same trend is observed for systolic and diastolic blood pressure, which is worse in 12-year-old children. More than 90% of blood pressure is above normal. We see the reason for such results in the fact that 12 years is a "critical" period of ontogenesis. Physiological and anatomical age changes in the circulatory system at this age may lead to increased values of absolute hemodynamics of heart rate and blood pressure.

The Robinson index as an indicator of the level of cardiovascular function, an indicator of the nature of the regulation of the cardiovascular system, systolic heart rate and physical health was determined in the two groups of 11 and 12 years. A comparison with the literature data makes it possible to say that the obtained data indicate the best functional state of the cardiovascular system in our subjects. According to our research, the average level of the Robinson index available for children 11 and 12 years is at a level "below average". A lower than average value of the Robinson index showed a shift in the regulation of the cardiovascular system in the group of 11, 12 years towards the sympathetic nervous system and below the average functionality of the cardiovascular system. The Robinson index indicates the maximum aerobic capacity of the body, which in turn is part of the characteristics of the level of physical health of the child. Regarding the characteristics of the functional state of the cardiovascular system of children of two ages and their maximum aerobic capacity, slightly worse reserve capacity and functional state of the cardiovascular system were found in the group of 12 years. This was confirmed by the analysis of the percentage of children in the two groups with high and above average levels of the Robinson index and the absolute Robinson values. The percentage of those who are dominated by the sympathetic nervous system and there is a shift towards sympathetic

regulation in 12-year-old children is 13.3% and 16.7, respectively. Of the total number of subjects in 11-year subjects can be found such a large number (about 35.5% and 8.8% of students with sympathetic regulation and strong dominance of the sympathetic system), which can further lead to reduced functional capacity and the body. Studies have shown that in children of the surveyed age groups, a number of indicators of the functional state of the cardiovascular system were "below average". It should be noted that a significant number of children studied showed a pronounced effect of the sympathetic division of the autonomic nervous system, which affects their functional capabilities of the body. If the sympathetic nervous system dominates or is present, there is a risk of cardiovascular overstrain. This increases the sensitivity of such children to various factors and the risk of pathologies of the cardiovascular system.

One of the reasons for the results of the worst functional state of the cardiovascular system, according to the results of hemodynamics, Robinson's index - is the heterochrony of the development of the systems of Otronism in ontogenesis. Systems develop according to this pattern, which is a physiological feature of the physical development of the organism. Plus, our data confirm that the period of 12 years is a "critical" period of ontogenesis, especially in relation to the cardiovascular system, which in turn is due to the unevenness, heterochrony of development.

Indicators of adaptive capacity of the cardiovascular system of middle-aged children aged 11-12 were studied. As a result of the study it was found that in the age group of 11-12 years a significant proportion of children have unsatisfactory adaptation (53.25%). Regarding the characteristics of the adaptive capacity of the cardiovascular system of children of two age groups, the worst adaptive capacity of the cardiovascular system was found in the group of 12 years, also there is a higher percentage of children with unsatisfactory adaptation (76.67%).

In our opinion, along with the "critical period" and the uneven growth and development processes, the reasons are also a factor of reduced motor activity and increased anxiety, stress. In the literature there is a high level of anxiety in children and low levels of stress resistance [8, 12, 13, 14]. Negative experiences, the dominance of negative emotions over positive ones cause psychological stress. Lack of physical activity has a negative effect on the functional state of the body, the health of the population.



CONCLUSIONS.

1. Thus, it is possible to state a significant percentage of children with low levels of reserve and functional capabilities of the cardiovascular system. Sympathetic regulation of the cardiovascular system and strong dominance of the sympathetic system is present in 30% of 12-year-old children. No children with a high Robinson index among 12-year-olds were found. Analysis of the percentage of Robinson's index and its indicators in children showed that high and above average physical health in the group of 11-year-old children in the amount of 23.5%. The results of the Robinson index give grounds to state that in children aged 11 and 12 the functionality of the cardiovascular system is at a level "below average". In children 12 years of age, the functionality of the cardiovascular system is slightly lower.

2. The average indicators of adaptation potential of the first group of children 11 years old indicate the stress of adaptation (1.9 ± 0.2 conventional units) In the second group of 12 years the level of adaptive capacity decreases sharply. Indicators of adaptation potential in the group of 12 years correspond to unsatisfactory adaptation. The obtained research results are also a confirmation of the negative dynamics of the functional state, reserves and regulation of the cardiovascular system in the studied children.

3. After the examination for children with low indicators of the functional state of the cardiovascular system, reserves and regulation of the cardiovascular system, recommendations on lifestyle were provided in order to prevent problems with the cardiovascular system. Preventive measures have been developed, which have been included in the health programs of the children's camp. In order to improve the functional state of the cardiovascular system of schoolchildren, one of the effective actions is to reduce the impact of hypodynamics, the introduction of health technologies, health programs, it is necessary to promote healthy lifestyles among children, the need to take care of their health.

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