

Functional Condition of Ukrainian Schoolchildren with Chronic Heart Failure of I–IIA Stages

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Abstract:

It is found that heart failure remains one of the most urgent problems of modern children's cardiology. Exactly chronic heart failure causes a violation of the state of health, limitation of vital functions. It is carried out a rehabilitation examination of Ukrainian school age children with chronic heart failure of I-IIA stages. It made it possible to determine the functional state of the cardiovascular and respiratory systems, the state of the autonomic nervous system. According to the complex examination's results, the physical rehabilitation program can be made. Physical training should be a key element of cardiac rehabilitation in chronic heart failure. The rest is not recommended for such patients, regardless of the stage of the disease.

Key words: physical rehabilitation, schoolchildren, chronic heart failure, complex examination.

Introduction.

The cardiovascular pathology is one of the leading places among childhood diseases (Surkov, 2015). Heart failure (CH) as the most frequent complication of cardiovascular disease (CVD) prematurely leads to disability, decreasing quality of life and premature death (Voronkov et al., 2012; Chazov et al., 2005). Chronic heart failure (CHF) is one of the final stages of the continuous development of cardiovascular disease (Emets et al., 2013; Madriago, 2010), which results in an unfavorable prognosis and reduction of tolerance to physical activity (Voronkov et al., 2012; Recommendations of the Association of Cardiologists of Ukraine, 2017; ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure 2012; Tracie et al., 2005). Exactly CHF causes a violation of the state of health, limitation of vital functions and necessitates the social protection of these sick children.

It is observed the negative tendencies in increasing the number of children suffering from this pathology. The prevalence of circulatory system diseases increases with age, which is confirmed in the Annual report on the health status of the population, the sanitary-epidemiological situation and the results of the healthcare system of Ukraine for 2016 (2017): 0-6 years - 12.14; 7-14 years - 40.11; 15-17 years old - 77.98 children per 1,000.

Despite the advances in modern medicine, the incidence of hospitalizations and mortality in CHF is high (Voronkov et al., 2012; Pellicori et al., 2016). According to A.N. Parkhomenko (2014), heart failure remains one of the most urgent problems in cardiology.

As it is known, a number of scientists consider the physical activity of a patient as one of the components of CHF treatment (KNGF Clinical Practice Guideline for physical therapy in patients undergoing cardiac rehabilitation, 2011; Tracie et al., 2005). Scots (UK) also consider physical training as a key element of cardiac rehabilitation in CHF (Cardiac rehabilitation. A national clinical guideline. Scottish Intercollegiate Guidelines Network; 2002). After all, physical activity contributes to the achievement of the goals in the treatment of CHF. In spite of significant advances in medicine, particularly in surgical treatment, physical rehabilitation is currently inadequate. Today, cardiac rehabilitation is limited in Ukraine really (Dzyak et al., 2004), because the standards of medical rehabilitation do not exist, its quality largely depends on the doctor's qualifications, the level of the hospital, the awareness by the patients themselves of the need for physical rehabilitation (Klimenko & Denisenko, 2010). Any conservative or surgical treatment of patients with CVD can not be considered complete without physical rehabilitation.

Purpose of the research - to investigate the functional state of the cardiovascular, respiratory and nervous systems of Ukrainian children of school age with chronic heart failure of I-IIA stages.

Materials & methods:

In our research we used theoretical and empirical methods: analysis and generalization of library resources, documentary method; clinical (laboratory and instrumental methods, methods of functional diagnostics), methods mathematical statistics.

34 school age children (6–17 ages) with CHF I–IIA stages were engaged to the research with congenital heart defects, cardiac arrhythmias, cardiomyopathies and pathology of pericardium.

According to the International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10), the diagnosis of children in this study was consistent with the codes: Q classes (congenital malformations, deformations and chromosomal abnormalities), and I (circulatory system diseases) and Q20-Q28 blocks (congenital malformations of circulatory system development) and I40- I49 blocks (other heart conditions). The nosology of the I50 (heart failure) was also common to them.

Results.

In Ukraine, the achievement of the goals of CH treatment is carried out by pharmacological means in most cases. The causes of CH in children may vary, depending on age and concomitant illness. The most common causes of CH in children are congenital heart disease, primary lesion of the myocardium (cardiomyopathy), inflammatory myocardial infarction (myocarditis), arrhythmias, pericardial pathology.

Treatment of patients with cardiovascular disease can not be considered complete without physical rehabilitation. According to Amosov M.M. & Bendet Y.A. (1990), increasing functionality of the cardiovascular system (CVS) is a main goal in the treatment of patients with CHF. In spite of this, the current normative legal documents of Ukraine do not cover the process of physical rehabilitation of people with CHF, in particular their physical activity (Bogdanovska, 2017). Exclusion of physical activity for patients with CHF is not desirable, since it contributes to the deconditioning and reduction of adaptive mechanisms of the cardiovascular system (Basargina et al., 2010; ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure 2012). And precisely the deconditioning can be evaluated as a risk factor for death in CHF (Voronkov et al., 2012). So today it is clear that rest is not recommended for patients with CHF, regardless of the stage of the disease.

The main to choose a regime of physical activity to patients with CHF is determination their initial functional status. That is why we conducted this research, which will facilitate the development of a program of physical rehabilitation for school-age children with CHF of I-IIA stages.

For conducting a pedagogical experiment, we conducted a cardiological and further rehabilitation examination (Chekhovska, 2016). For the complex perception of the cardiac patient, there is a necessity of examination only of CVS but also of the psycho-emotional state and quality of life, of the functional state of the musculoskeletal system, of the cardiorespiratory and autonomic nervous system of children with CHF (Chekhovska, 2016). This complex approach has made it possible to detect various violations by different body systems and take into account the individual peculiarities of the child while sectioning means of physical rehabilitation.

Taking into account that the children under examination had a wide age range (6-17 years old), the indicators of heart rate, blood pressure, respiratory rate and others were evaluated by a nonparametric standard, so the obtained values were compared with the values of percentile (centile) tables according to age and sex (On the comprehensive assessment of the health of children: the order of the Ministry of Health of the Russian Federation, 2003; Fleming et al., 2011). The percentile corridors and grading of the level of indicators were as follows: I - to 5 (3, 1)% - very low, II - 5 (3, 1) -10% - low, III - 10-25% - below average, IV - 25 -75% - average, V - 75-90% - above average, VI - 90-95 (97, 99)% - high and VII - more than 95 (97, 99)% - very high (Fleming et al., 2011).

The state of the cardiovascular system of the cardiac patient depends on the depth of manifestation of the symptoms of the underlying disease and its consequence (complication) – chronic heart failure.

Examination of CVS in the studied children with CHF of I-IIA stages found that in most of them (58.82%), heart rates were beyond the mean values (Fleming et al., 2011) despite medication (due to the underlying cardiac disease). So, an increased heart rate was established in 47.05% of the examined children, that is, the heart uses reserve features, which is a characteristic feature of CHF (Table 1).

Table 1. Distribution of Indicators of Heart Rate and Respiratory Rate of School Age Children with Chronic Heart Failure I-IIA Stages according to Percentile Tables (n = 34)

Percentile corridors	Level of indicators	HR, %	RR, %
up to 1%	very low	2,94	2,94
1-10 %	low	2,94	2,94
10-25 %	below average	5,88	2,94
25-75 %	average	41,18	29,41
75-90 %	above average	35,29	14,71
90-99 %	high	11,76	35,29
above 99 %	very high	-	11,76

The heart rate below 10 percentiles was found in 5.88% of the children under study with CHF, indicating a weakened heart function.

The CVD examination in children with CHF I–IIA stages revealed, despite medical therapy (constant / episodic), that in 47.06% of children have accelerated heart rate (HR), that is, the heart uses the reserve

capacity, which is a characteristic feature of this syndrome. In 32.35% of children of blood pressure systolic (BPs) and in 44.12% of children of blood pressure diastolic (BPd) were above average values. 70.6% of children were found to have high energy expenditures for blood flow through the body, and the aerobic capacity of the body in 47.06% and 32.35% of children was assessed as low and below average respectively. This negatively characterizes the functioning of the blood circulation system. In 32.35% of the children surveyed, adaptation was ensured through the mobilization of functional reserves.

Blood pressure is also an important indicator of the functioning of the CVS and one of the most objective indicators of hemodynamic. The results of the measurement of blood pressure in children are presented in Table 2.

Table 2. Distribution of Indicators of Blood Pressure of Children of School Age with Chronic Heart Failure I-IIA Stages in accordance with Percentile Tables (n = 34)

Percentile corridors	Level of indicators	BPs, %	BPd, %
up to 3(5)%	very low	-	-
3(5)-10 %	low	8,82	2,94
10-25 %	below average	11,76	2,94
25-75 %	average	41,18	44,12
75-90 %	above average	23,53	26,47
90-97(95) %	high	8,82	17,65
above 97(95) %	very high	5,88	5,88

The values of BP below 3 (5) and above 97 (95) percentiles indicate hypotension and hypertension, respectively. In our study, values above 97 (95) percentiles were found in 5.88% of children in the results of both systolic and diastolic blood pressure. Elevated blood pressure, which is above 75 percentiles, can be observed in 38.23% (BPs) and 50% (BPd) of school-age children with CHF, which is another risk factor for cardiovascular disease. After all, the connection between the values of blood pressure and cardiovascular diseases is established and set out in the recommendations of the European Society of Hypertension and the European Society of Cardiology (ESH / ESC, 2013). The value of the coefficient of efficiency of blood circulation (CEC) shows potential opportunities of the blood circulation system (Table 3).

Table 3. Examination of the Functional State of School Age Children with Chronic Heart Failure of I-IIA Stages

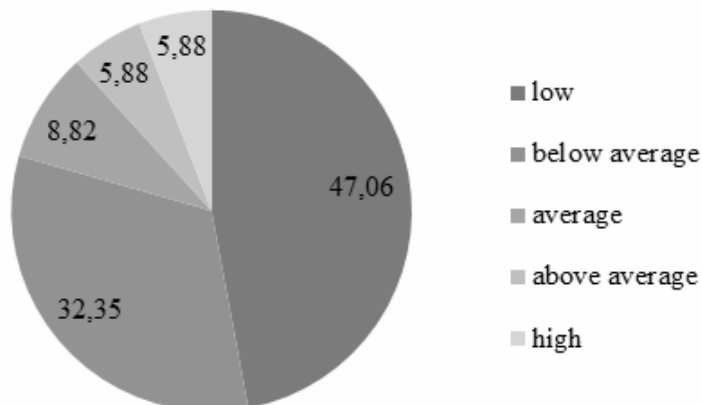
Indicator	Value		
	$x_{cep} \pm m$	Me	N
CEC b (n=15)	3266,67±236,63	3280	2400-3200
CEC g (n=19)	3335,26±190,79	3360	2600-3400
Wlv, (n=34)	1,09±0,04	1,06	decrease
LI b (n=15)	50,33±1,78	52,86	65-70
LI g (n=19)	44,83±1,68	44,78	55-60
Hildebrand coefficient (n=34)	4,33±0,2	4,19	2,8-4,9

Note. b - boys; g - girls.

Only 29.4% of all examined children were within normal limits of the absolute values of this coefficient, and accordingly, 70.6% of children with CHF had high energy expenditure on blood flow in the body. The power of the left ventricle (Wlv) is an indicator that also characterizes the effectiveness of the heart muscle. It can be estimated only in dynamics, since its decrease is positive.

We also calculated the Robinson index to assess the aerobic capacity of children, whose results are presented in Figure 1.

Figure 1. Aerobic Possibilities of an Organism of Children of School Age with Chronic Heart Failure of I-IIA Stages According to Robinson's Index (%)



As we can see, the Robinson index is rated as low and below average at 47.06% and 32.35% of children respectively, which characterizes the functioning of the CVS negatively. Consequently, the growth of this index indicates an increase in the intensity of the heart (Chekhovska, 2017). Unfortunately, but CVS functions effectively only in 5.88% of the examined children, indicating the severity of the current syndrome and the probability of complications from progression.

Adaptation of the organism to changing environmental conditions is by mobilizing the reserve capacity of the organism.

According to our research, the adaptive potential of CVS was evaluated as satisfactory in only 41.18% of children, in 32.35% of the surveyed the tension of adaptation mechanisms was observed, that is, the functional capabilities of the child's body are provided through the mobilization of functional reserves. And in 11.76% of schoolchildren, the potential of the circulatory system was accompanied by a sharp decline in the functional capacity of the body.

Adaptation to environmental conditions that is characterized by functional capabilities is one of the integral indicators of the physical condition of the child.

The saturation, as an index of oxygenated blood saturation, in the researched sample in a state of rest ranged from 89% to 97%. The average statistic was $93.68 \pm 0.37\%$, which is below normal and one of the characteristic manifestations of heart failure. In our opinion, this may also be due to the inadequate presence of schoolchildren in the open air.

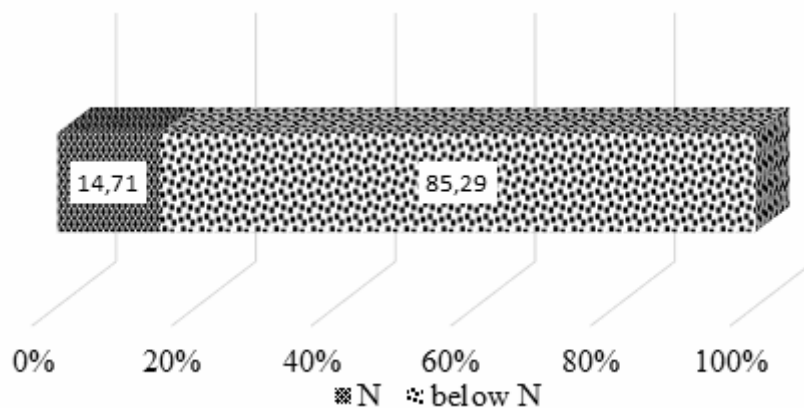
Investigating the function of external respiration, along with the study of the cardiovascular system allows us to assess the functional state of the child and reserve capacity of his/her body. It is established that the system of external respiration plays an important role in ensuring the adaptation of the body to physical activity of varying intensity and power (Emets et al., 2013).

The examination of the respiratory system (Chekhovska, 2017) made it possible to find that in a state of rest, 47,06% of children have respiratory rate (RR) above 90 percentiles (see Table 1). Accelerated breathing (tachypnoe) can be a symptom of the onset of respiratory failure in the course of heart disease. It is pathological shortness of breath observed in diseases of the cardiovascular and respiratory systems and is manifested by violations of frequency, depth and rhythm of breathing.

The respiratory rate in 5.88% of the examined children was lower than 10 percentiles that is slow (bradypnoe), which, unfortunately, indicates a decrease in the function of the respiratory center. And only 29.41% of schoolchildren with CHF have mean percentile (25-75 percentiles) values of RR.

It is known lung capacity (LC) is one of the most important indicators of the functional state of external respiration. This complex indicator depends on the total volume of lungs, pulmonary tension, lumbar motility and respiratory muscle strength, and is widely used in the study of functional status (Emets G.V. et al., 2013). We have established (Chekhovska, 2017) that only in 14.7% of children the ratio LC to proper size (PLC) was within normal limits (Figure 2), calculated according to the Ludwig formula (Ivasyk, 2012), and 85.29% of schoolchildren with CHF have a lower LC to proper value.

Figure 2. Ratio of Life Capacity of Lungs to Proper Value in School Age Children with Chronic Heart Failure of I-IIA Stages



For a more objective assessment of the external respiration, we also relied on living index (LI) (Chekhovska, 2017), which is more informative indicator than LC. The results of the examination of the development of the lungs show that in 94.12% of children received indicators do not meet the normative values. The average of this index in both boys and girls is significantly lower than the regulatory range (see Table 3). And low values of LI confirm the low reserve capacity of the external breathing apparatus of the children.

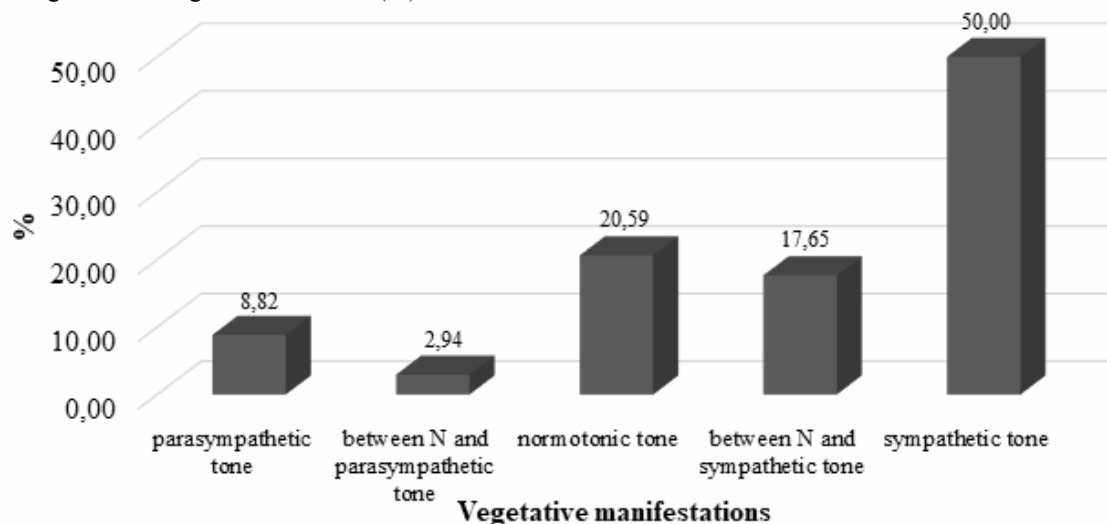
The autonomic nervous system (ANS) not only regulates the maintenance of homeostasis, but also is responsible for the energy supply of various forms of adaptation of the organism to new conditions of existence (the change of the usual rhythm of life, a large emotional load, etc.).

Since the central place in the integration of complex reflex responses of the human body belongs to the ANS, we calculated the vegetative Kerdo index (Rekova & Dmitrieva, 2004) and the Hildebrand coefficient (Malikov et al., 2006) to assess the nature of vegetative changes.

Thus, the Hildebrand coefficient allowed to establish inconsistencies in vegetative regulation of various visceral systems in 23.53% of the examined children, despite the fact that the average value of this indicator was within the normal range (Table 3). Reducing the Hildebrand coefficient indicates excessive energy costs and, accordingly, violations of inter-system relations.

Vegetative index, which characterizes the degree of involvement of the sympathetic and parasympathetic parts of the ANS in the regulation of blood circulation, showed the prevalence of excitatory effects (sympathetic manifestations) in 50% of patients (Chekhovska, 2017). Results of the study of the direction of the functions of the autonomic nervous system according to the Kerdo index are shown in Figure 3.

Figure 3. Results of Study of Vegetative Tone in Children of School Age with Chronic Heart Failure I-IIA Stages According to Kerdo Index (%)



Thus, for the correct formation of adaptive reactions at young age, it is required a constant dosed physical activity to train compensatory mechanisms.

According to the correlation analysis we established a direct correlation between the index of heart rate and the vegetative index, and their very strong relationship ($r=0.9$, $p\leq 0.01$). That is, the predominance of excitatory or inhibitory processes directly depends on the child's heart rate. Also, direct and very strong left ventricular power connections are established with Robinson's index ($r=0.98$, $p\leq 0.01$) and adaptive potential ($r=0.93$, $p\leq 0.01$). If the index Wlv increases (its function deteriorates), then the value of the Robinson index increases, and an increase in the intensity of the heart work indicates a decrease in the aerobic capacity of the CVS and its ineffective functioning. Similarly, an increase in the Robinson's index (its deterioration) contributes to the increase of left ventricular power. Accordingly, there is a direct dependence of the Wlv and adaptive potential, which means deterioration of these indicators with the growth of any of them. Thus, with the reduction of adaptive capacities, the power of the left ventricle increases or with its increase, the adaptation of the CVS deteriorates to external factors. The Robinson index and AP also have a direct and strong connection ($r=0.86$, $p\leq 0.01$). In addition, we established another direct and strong connection between the Wlv and CEC ($r=0.84$, $p\leq 0.01$). Their simultaneous reduction will positively characterize the functioning of the blood circulation system. However, negative tendency of one, will negatively affect the other one.

In the next publication, we will present the state of the musculoskeletal system, physical development and tolerance to physical activity of school-age children with chronic heart failure of I-IIA stages.

Conclusion

The examination of the cardiovascular system in children with chronic heart failure of the I-IIA stages made it possible to detect, despite the medical therapy (constant/episodic), that heart rates in the majority of children (58.82%) are within the average range (25-75 percentiles). However, 47.06% of children have an accelerated heart rate, which means that their heart uses reserve features. In 5.8% of children, BP (systolic and diastolic) is higher than 97 (95) percentiles. BPs and Bpd were above 75 percentiles in 32.35% and 44.12% of children appropriately. The potential opportunities of the blood circulation system is evidenced by the importance of the coefficient of efficiency of blood circulation, where 70.6% of children have high energy costs for blood flow through the body. It was found that the body's aerobic capacity is estimated to be low and below the average in 47.06% and 32.35% of children, respectively. This negatively characterizes the functioning of the blood

circulation system. That is, the growth of this index indicated an increase in the intensity of the heart work. Satisfactory compensatory responses (adaptive potential) were established in 41.18% of children, however, 32.35% were provided with the mobilization of functional reserves.

The examination of the respiratory system made it possible to detect respiratory rate above 99 percentiles in 11.76% of children at rest state. The ratio of the lung capacity to the proper value was within the normal range only in 14.7% of children. Assessment of the development of the lungs showed that values are lower than the norm in all boys and in girls - only 10.5% of the obtained indicators correspond to the norm.

The Hildebrand coefficient in 23.53% of the examined children showed inconsistencies in the vegetative regulation of various visceral systems, despite the fact that the average value of this indicator is within the normal range. Vegetative index showed the prevalence of excitatory effects in blood circulation regulation in half of patients.

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