Dynamics of physical development of children with functional single ventricle heart disease at the individual stages of physical rehabilitation

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Abstract

Background: Physical development of children is an important indicator of health. The study aimed to evaluate the dynamics of physical development indicators of children with functional single ventricle heart disease at the individual stages of physical rehabilitation.

Methods: A group of 35 patients aged 6 to 14 years was examined during hospitalization; 31 of them underwent follow-up examinations after completion of the full course of physical rehabilitation. The following indicators were measured: the body weight, height, chest circumference, body surface area, and Rohrer index.

Results: We did not find significant differences between the groups of boys and girls of the same age. A substantial share of children with functional single ventricle was characterized by reduced body weight, which was reflected by the distribution of Rohrer index, where the percentage of children with low values was 31.5%. After completion of the course of physical rehabilitation, the indicators of physical development were statistically improved and the share of children with low values of the Rohrer index decreased to 16.1%.

Conclusions: Physical therapy positively affects the physical development of children with functional single ventricle heart disease.

Key words: congenital heart disease, functional single ventricle, physical development, rehabilitation, physical therapy.

Introduction

Nowadays, all known cardiac surgical procedures are performed in Ukraine in patients with the most severe congenital heart defects (CHD) [13]. According to the literature, severe congenital heart defects include functional single ventricle (FSV) heart disease, which implies mixing of pulmonary venous and systemic venous flow.

Given the hemodynamic characteristics of these patients, it is relevant to study various aspects of their physical health [2, 5, 8], benefits of physical exercise [6, 7], and effects of surgical treatment and programs of physical rehabilitation [10, 11, 12]. The children with congenital heart diseases have been reported to show a delay in physical development [9].

The physical development of children is influenced by climatic and geographical features of the region of residence, housing and living conditions, day regimen, nutrition, as well as by previous or chronic diseases. The rate of physical development is also affected by hereditary factors, metabolic rate, body constitution, and hormonal background. The height of a child is the most stable characteristic compared to the other indicators of physical development [1].

The aim of the study was to evaluate the dynamics of physical development indices of

children with functional single ventricle heart disease at the individual stages of physical rehabilitation.

Materials and methods

The study involved 35 patients with FSV hospitalized for surgical treatment in the Scientific-Practical Medical Center of Pediatric Cardiology and Cardiac Surgery, Ministry of Health of Ukraine between 2013-2015, including 23 boys (65.7%) and 12 girls (34.3%) aged 6 - 14 years on admission to hospital. Twenty-nine (82.9%) patients were hospitalized to undergo a complete cavopulmonary anastomosis procedure, and in six (17.1%) patients, a modified Glenn anastomosis was performed.

The follow-up was performed after completion of the physical rehabilitation course (168.68 ± 66.90 days). The age range of patients (n = 31) was 7 to 14 years.

Instruments

Anthropometric measurements were taken using standard equipment and a uniform test procedure in collaboration with the attending physician. The following indicators were measured: the body weight, height, chest circumference (CC), body surface area (BSA), and Rohrer index (RI).

Since the age range of children was wide, body weights and heights were assigned to centiles according to the reference charts for appropriate age and gender [1].

The level of physical development of a child was considered normal or average at RI values ranging from 10.7 to 13.7 $kg \cdot m^{-3}$, as low at RI values of 10.7 $kg \cdot m^{-3}$ or less, and as high at RI values above 13.7 $kg \cdot m^{-3}$ [3].

Data Analysis

Statistical analysis was performed using Statistica software (version 6.0).

For quantitative variables with normal distribution, the mean ($\overline{x}$) and standard deviation (S) were calculated. For quantitative variables without normal distribution, the median and the upper and lower quartiles (25% to 75%) were calculated.

For variables with normal distribution, Student's *t* test (for independent and dependent samples) was run to assess the significance of the difference, and for variables without normal distribution, U-criterion of Mann-Whitney (for independent samples) and Vilcocson criterion (for dependent samples) were applied.

Correlation analysis was performed to examine relationships between the indicators of physical development and the results of other clinical tests.

Results

The morphological characteristics studied included the body weight, height, chest circumference (CC) during quiet breathing, body surface area (BSA), and Rohrer index (tables 1 and 2). The body weight of children with functional single ventricle heart disease was 28.00 (the range 22.00- 32.00; Me [25%, 75%]) kg, and the mean height was 136.43±14.00 cm. The minimum values of body weight and height were 16 kg and 115 cm, and the maximum values were 55 kg and 170 cm, respectively. The Rohrer index was 11.45±1.79 $kg \cdot m^{-3}$ that reflects harmonious relationship between the body weight and height in most children.

The maximum value of CC was found to be at the level of 90 cm and the minimum was 54 cm. The BSA was 1.03 (0.87; 1.14) m^2, the minimum value of BSA was 0.7 m^2 and the maximum value was 1.6 m^2.

The analysis of indicators of physical development (table 2) showed no statistically significant difference between the groups of boys and girls of the same age ($p>0.05$) that allows us to

Table 1. The average values of the indicators of physical development of children with functional single ventricle heart disease during hospitalization (n = 35)

Indicators of physical development	$\overline{X}$	S	Me	25%	75%
Height, cm	136.43	14.00	133.00	125.00	144.00
Body weight, kg	29.72	9.94	28.00	22.00	32.00
SS, cm	64.97	6.94	64.00	62.00	67.00
BSA, m^2	1.05	0.22	1.03	0.87	1.14
RI, $kg \cdot m^{-3}$	11.45	1.79	11.13	10.23	12.75

Table 2. The average values of the indicators of physical development of boys and girls with functional single ventricle heart disease during hospitalization

Indicators of physical development	Age	Gender	$\overline{X}$	S	Me	25%	75%	p
Height, cm	6-9	Boys (n = 12)	125.9	6.5	125.5	121.0	131.8	>0.05
		Girls (n = 7)	128.0	7.9	125.0	122.0	132.0	
	10–14	Boys (n = 11)	148.3	12.4	148.0	137.0	158.0	>0.05
		Girls (n = 5)	147.4	9.1	144.0	139.5	157.0	
Body weight, kg	6-9	Boys (n = 12)	24.9	5.2	26.0	19.3	29.9	>0.05
		Girls (n = 7)	24.1	7.7	21.8	19.0	25.0	
	10–14	Boys (n = 11)	36.8	11.6	36.0	27.5	48.0	>0.05
		Girls (n = 5)	33.6	7.5	31.0	29.5	39.0	
SS, cm	6-9	Boys (n = 12)	62.3	4.9	63.5	58.3	64.9	>0.05
		Girls (n = 7)	60.6	4.1	60.5	57.0	63.5	
	10–14	Boys (n = 11)	69.9	8.3	67.5	64.0	75.0	>0.05
		Girls (n = 5)	66.5	4.8	64.5	64.3	69.8	
BSA, m^2	6-9	Boys (n = 12)	0.9	0.1	0.9	0.8	1.0	>0.05
		Girls (n = 7)	0.9	0.2	0.9	0.8	0.9	
	10–14	Boys (n = 11)	1.2	0.2	1.2	1.0	1.5	>0.05
		Girls (n = 5)	1.2	0.2	1.1	1.1	1.3	
RI, $kg \cdot m^{-3}$	6-9	Boys (n = 12)	12.4	1.9	12.4	10.9	13.5	>0.05
		Girls (n = 7)	11.3	1.5	11.3	10.2	12.0	
	10–14	Boys (n = 11)	11.0	1.8	11.1	9.7	11.2	>0.05
		Girls (n = 5)	10.4	1.4	11.1	9.0	11.6	

further analyse the indicators for a mixed group of children and indicates that diagnosis is the major factor for grouping these children.

Figure 1 demonstrated a substantial increase in the number of children with very low body weight (14.3%) in the group with FSV, as compared to the norm (3%). The distribution of height to centiles was generally not different from the norm.

The distribution of children by Rohrer index was as follows: 31.5% - a low level of RI (underweight), 57.1% - an average level of RI (the balanced height-to- weight ratio), and 11.4% - a high level of RI (overweight).

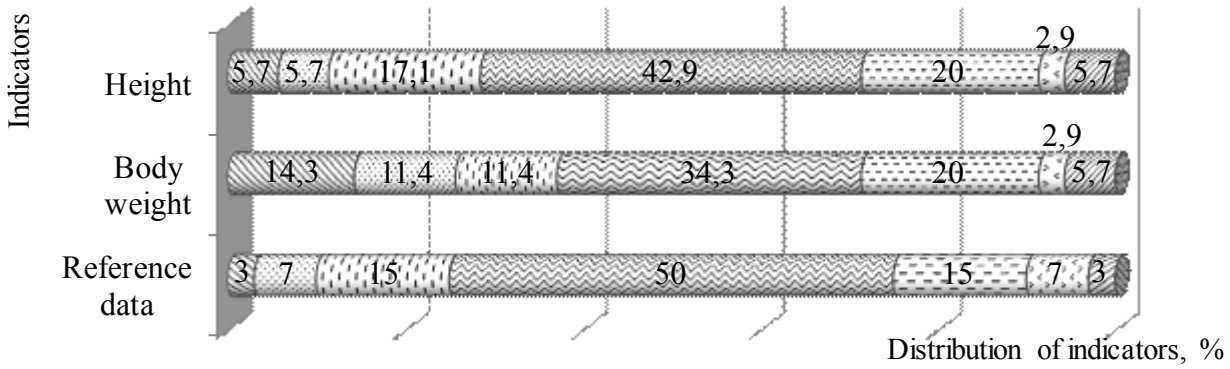

Fig. 1. The distribution to centiles of the height and body weight of children with functional single ventricle heart disease (n=35):

- very low;
- low;
- lower than average;
- average;
- higher than average;
- high;
- very high

The above findings revealed the predominance of underweight children in the study sample.

A comprehensive program of physical rehabilitation was started before surgery and ended in the home settings. The features of the physical rehabilitation program used for the children in this study were published earlier [11].

Analysis of the results of a formative experiment and effects of physical therapy revealed positive changes in the indicators of physical development (table 3) measured at follow-up.

The height of patients at follow-up (n = 31) increased by an average of 2.6 cm ($p<0.01$), body weight increased by an average of 2.6 kg ($p<0.01$), CC increased by 1.5 cm ($p<0.01$), BSA increased by 0.07 m^2 ($p<0.01$), RI increased by 0.24 $kg \cdot m^{-3}$ ($p<0.05$).

Figure 2 demonstrated the changes in distribution by centiles of height and body weight of children at the beginning and at the end of the study. Analysis of the parameters disclosed that the percentage of children at the 4th centile (middle)

Table 3. The average values of the indicators of physical development of children with functional single ventricle heart disease at different stages of the study

Indicators of physical development	At the time of hospitalizations (n=35)		At follow-up (n=31)	
	$\bar{x}$	S	$\bar{x}$	S
Height, cm	136.43	14.00	136.52**	12.38
Body weight, kg	29.72	9.94	30.95**	10.04
SS, cm	64.97	6.94	65.71**	6.89
BSA, m^2	1.05	0.22	1.09**	0.21
RI, $kg \cdot m^{-3}$	11.45	1.79	11.93*	1.67

*Notes: the differences are statistically significant at the level of confidence of: * p<0.05; ** <0.01.*

for height increased by 5.5%, but this increase was due to almost equal decreases in the number of children that were in the upper and lower centiles.

The changes in body weight distribution were more substantial. The number of children at the 4th centile (middle) of body weight increased by 10.9% at the end of the study and this increase resulted only from a decrease in the number of underweight children. Furthermore, the total percentage of children at 5th–7th centiles increased.

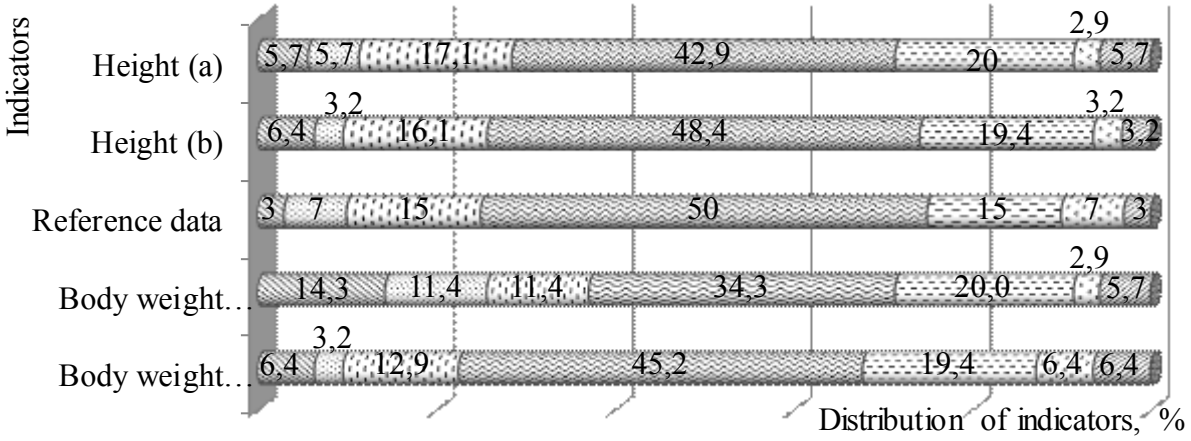

Fig. 2. Distribution to centiles of children with functional single ventricle by body height and weight at the moment of hospitalization (a; n-35) and at follow-up (b; n-31):

- very low;
- low;
- below average;
- average;
- above average;
- high;
- very high

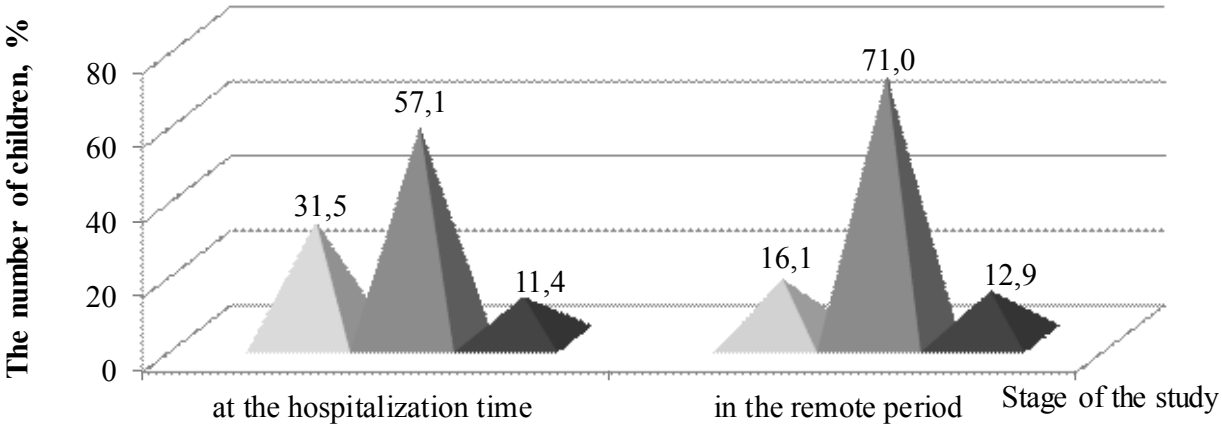

Fig. 3. The distribution of Rohrer index in groups of children with functional single ventricle heart disease at different stages of research:

- low;
- average;
- high

The above changes were confirmed by the analysis of Rohrer index dynamics (Fig. 3). At follow-up, 71,0% of children had the average level of RI, i.e. 12,9% higher than at the hospitalization time.

The percentage of children with high levels of RI was 12.9%, which was also higher than that during the first examination. We concluded that the decrease in the number of children was observed only in the group with a lowered Rohrer index. Therefore, the dynamics of changes in RI was similar to the changes in body weight distribution by centiles.

The changes in body weight at follow-up were more substantial in children with lower baseline values of RI (ρ = -0.53, $p<0.01$) and pulmonary-to- systemic blood flow ratio Q_p/Q_s (ρ = -0.41, $p<0.05$), which was also proved by greater changes in RI in children with lower baseline values of RI (ρ = -0.45, $p<0.05$).

Discussion

Impaired physical development has been documented even among the children with mild congenital heart disease [14]. Furthermore, 78% of patients with FSV have been reported to demonstrate a lag in physical development [15]. Likewise, the data from some other studies[16, 17 have shown that during the preoperative examination, the majority of patients with congenital heart disease (CHD) had significant physical developmental abnormalities: delayed growth, lower body weight, and reduced strength development.

As noted by A. Adomaitis [18],"the effects of congenital heart defects on the physical development have been studied for almost a hundred years, but their influence on the processes of growth is still described only in general terms."

Conclusions.

Children with functional single ventricle heart disease demonstrate not only unique parameters of blood flow, but also substantial peculiarities of physical development. Both in boys and girls, the main indicators of physical development, including index figures, have a tendency to decrease. Physical rehabilitation positively affects the physical development of children and reduces the percentage of children with lower values of indicators.

Further research should focus on the physical development and its dynamics among children with other congenital heart diseases.

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