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The Physical Condition of Deaf Primary School-Age Children and How to Correct it Using Physical Education Methods

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Abstract: The latest studies have shown that the parameters of physical development of children with hearing loss are attracting the attention of the scientific community. However, there are few studies that investigate changes in the physical condition of deaf children after improving physical education. The purpose of this work is to study the physical condition of deaf primary school-age children and develop a corrective program using methods of physical education. The study included 72 deaf children (to the experimental nEG=37 and the control group nCG=35) and 28 primary school-age children with normal hearing. The choice of research sample was random and the age of the children ranged from 6-10 years old. The physical condition of the schoolchildren was determined using a set of medical and biological methods: blood pressure measurement, heart rate calculation according to the electrocardiogram R-R interval, spirometry, electrocardiography, echocardiography, physical work capacity (PWC150) test, measurement of catecholamines using E. Matlina's method, and anthropometry. The experimental physical education program consisted of a set of physical, breathing and posture exercises as well as physical games. Games were divided by complexity, level of perception, physical intensity, and impact on the body. It was determined that deafness negatively affects anthropometric indicators, the respiratory system, and the functional condition of the sympathoadrenal system, but does not affect the morpho-functional values of cardiac performance in primary school-age children. The study proves the effectiveness of adopting exercise programs based on physical games as a means of correcting the physical condition of deaf children. The study confirmed that the implementation of exercise programs for the correction of the physical condition of deaf primary school-age children by means of physical education based on physical games in the daily routine of special boarding schools has a positive effect on the children's respiratory, cardiovascular and sympathoadrenal systems.

Keywords: *physical condition; development; correction; means of physical education; physical games.*

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Introduction

Currently, sensorineural hearing loss in adults and children is a pressing problem. The number of people with this pathology is growing and is affecting younger and younger people with every passing year. According to the World Health Organization, over 5% of the world's population – or 430 million people – require rehabilitation to address their 'disabling' hearing loss (432 million adults and 34 million children). It is estimated that by 2050 over 700 million people – or one in every ten people – will have disabling hearing loss (World Health Organization, 2021). Preventive measures aimed at identifying and correcting hearing loss are cost-effective and can be very beneficial for children with deafness.

Dysfunction of the auditory system causes a number of secondary disabilities. The direct consequence of this pathology is speech development disorder, which leads to psychological, emotional and social underdevelopment of children's personalities (Peterson & Siegal, 1995; American Psychological Association et al., 2014). Researchers have noted in studies that children with hearing loss lag behind their normal-hearing peers in physical development (Engel-Yeger & Weissman, 2009; Melo et al., 2017; Wiegersma & Vander, 1983), have a higher heart rate, and lower blood pressure (Veena at al., 2015). Children with hearing pathologies also have a significant decrease in their body's ability to handle hypoxic states, limiting their level of physical performance (Sit et al., 2007; Lévesque et al., 2014). Hearing loss affects the vestibular and kinesthetic senses (Estil et al., 2003; Engel-Yeger & Weissman, 2009; De Kegel et al., 2014), which are associated with a delay in the ability to stand upright (Melo, 2017), decreased muscle tone, ability to maintain balance (Akınoğlu & Kocahan, 2018), underdevelopment of spatial orientation (Houde et al., 2016), difficulties differentiating motor sensations and performing complex coordinated movements (Masuda & Kaga, 2014; Rajendran & Roy, 2011; Stepanchenko et al., 2020; Veiskarami & Roozbahani, 2020). Motor and functional disorders due to the primary disability, concomitant diseases and secondary disabilities dictate the need for their correction (Fellinger et al., 2015; Goodwin, 2001; Lieberman et al., 2013). Many studies have been conducted on the correction of physical development of primary school-age children with hearing loss (Hartman et al., 2011; Peñeñory et al., 2018).

However, the authors only briefly mention changes in the body systems of deaf children and do not shed enough light on changes in their physical development using methods of physical education.

The purpose of the research is to study the physical condition of deaf children of primary school age and to develop a program for correcting it using methods of physical education.

According to the purpose of this research the following objectives were set:

Objective 1*. To determine the complexity and nature of physical and functional condition disorders of primary school age deaf children by the following indicators: anthropometry (height, body weight, chest circumference), spirometry (vital capacity of the lungs), physical performance (PWC150 test), electrocardiography, echocardiography, urine biochemical data.*

Objective 2*. To develop and experimentally substantiate the content of the physical condition correction program of junior schoolchildren with hearing deprivation by means of physical education.*

Objective 3*. To introduce the developed author's program into the educational process of special educational institutions and check its effectiveness.*

Materials & Methods

Subjects: The study included 72 deaf children ranging in age from 6-10 years old (27 girls and 45 boys). Participants consisted of 6-year-olds: six girls and ten boys; 7-year old's: seven girls and nine boys; 8-year-olds: three girls and ten boys; 9-year-olds: three girls and seven boys; 10-year-olds: eight girls and nine boys. Twenty-eight schoolchildren from School #55 in Lviv without hearing loss ranging in age from 6-10 years old also took part in the study. They consisted of 6-year-olds: three girls and three boys; 7-year-olds: five girls and five boys; 8-year-olds: four girls and two boys; 9-year-olds: one girl and two boys; 10-year-olds: one girl and two boys. Participants (72 deaf children) were randomly assigned to the experimental (nEG=37) and the control group (nCG=35). EG participants followed the authors' program during physical education classes, morning exercises, recesses, physical therapy classes, walks, and after school hours. CG participants took part in activities according to the school curriculum.

The study was conducted at Lviv Specialized Boarding School named after Maria Pokrova #101 and Zhovkva Education and Rehabilitation Center "Zlahoda" (West Ukraine) over the course of one school year. All the deaf children that took part in the study were seen by a medico-pedagogical committee, consisting of: doctor's otolaryngologists, deaf educators, psychologist. According to the medical assessment report, all of the children were almost deaf: 36% had acquired deafness and 64% had congenital deafness. ***Parents and their children agreed to participate in the study and were informed of the possibility of refusing to participate without any consequences for them.***

To determine the complexity and nature of disorders of physical and functional condition of deaf children and their hearing-impaired peers, two teams were created with the participation of the authors of the study. The first team was engaged in anthropometric measurements and determination of physical performance. The second team, which included cardiologists and biochemist, studied the functional status of the study participants.

Procedure: The following research methods were used in the study: summative and formative pedagogical experiment, medical and biological methods (blood pressure measurement, heart rate calculation according to the electrocardiogram R-R interval, spirometry, electrocardiography, echocardiography, physical work capacity (PWC_{150}) test, measurement of catecholamines using Matlina's method (1972), anthropometry, and statistical methods.

Exercise Program. After a period of observing the deaf children, the authors developed a program for correcting the children's physical condition. The program consisted of a set of corrective exercises including general physical, breathing and posture exercises as well as the basis of the program – physical games (Voinov, 2014). ***The games have been modified and adapted to the peculiarities of the development of deaf children. The program was implemented during one school year (32 weeks) by physical education teachers, study authors and deaf educators. When*** choosing a game, the duration of the game was taken into account (during physical education classes, morning exercises, recesses, physical therapy classes, walks, and after school hours). Safety was also taken into consideration during games (spotting and assistance were provided). During classes, high-intensity games were alternated with less intensive ones. Medical supervision dictated whether certain children with health issues could participate in the activities.

The use of motor games during morning gymnastics, physical education lessons, therapeutic physical education lessons, long breaks and walks comprised generally during the week: for children of preparatory class - 142-178 minutes; for children of the first class 156-190 minutes; for children of the second class - 160-200 minutes; for children of the third class - 174-217 minutes accordingly. On Mondays and Tuesdays, low- and medium-intensity games were introduced in

order to gradually prepare deaf children for physical activity. Medium and high-intensity games were used from Wednesdays to Fridays, as the children were already adapting to their existing work schedule. On Saturdays the games were mostly dominated by medium and low intensity games. Such a gradual plan for the introduction of motor games allowed us to determine their general direction. Given the special role of visual perception in the cognition of the world around deaf children, the predominance of imaginary thinking during the games using light stimuli, color equipment, drawings of individual elements of the game, headbands, colorful clothes, flags. In explaining the rules of the game, visualization was used in combination with dactyl, as well as performing actions by imitation and pattern.

The choice of physical games was based on the fact they not only help develop children's physical capabilities and locomotion, but also serve as an effective form of interpersonal communication and interaction with other children involved in the activity. All of these factors contribute to socialization, which according to researchers (Leigh et al., 2015; Peterson & Siegal, 1995) is harder for children with hearing loss.

The proposed exercise program, which includes sets of exercises for the prevention and correction of posture deficiencies, is also aimed at increasing the physical activity of deaf children who perform them during lessons, exercise breaks, and when doing homework. Thus, in general education lessons that require students to concentrate, pay attention, and stay seated, deaf children took exercise breaks. The signal that a break needed to be taken was when students started to exhibit waning attention spans, increased chattiness, reddened faces, sluggishness in their movements, or, conversely, an increase in movements in certain children. All this points to the fact that children get tired and it's advisable to stop the learning process to perform a set of exercises during a break. The exercise breaks consisted of a set of 3-4 general physical development exercises, which cover all major muscle groups. Each exercise was performed for 4-6 repetitions. After 2-3 weeks, the set of exercises was replaced by a different set.

Results

In accordance to the *Objective 1* of the research the following results were obtained represented in a Table 1, 2 below.

Table 1. Indicators of physical condition of deaf children of primary school age and children without hearing impairments

Source: authors'own contribution

Indices	Children aged	Sex	Deaf	Normal hearing
the height, cm	6-7	girls	111.85±0.39	113.25±1.09
		boys	112.63±0.44	114.00±1.05
	8-10	girls	120.36±0.61	121.33±1.14
		boys	122.12±0.44	124.17±2.40
the body weight, kg	6-7	girls	20.44±0.36	22.24±0.44
		boys	19.92±0.27	22.14±0.35
	8-10	girls	23.16±0.38	26.17±0.64
		boys	23.24±0.34	26.05±0.60
chest circumference, cm	6-7	girls	54.08±0.48	56.38±0.69
		boys	53.84±0.38	56.63±0.42
	8-10	girls	58.36±0.72	63.83±0.76
		boys	58.81±0.76	64.83±0.29
vital lung capacity, ml	6-7	girls	1046.15±24.29	1225.00±24.99
		boys	1200.00±27.57	1375.00±36.58
	8-10	girls	1396.43±36.53	1558.33±59.73
		boys	1473.08±26.34	1661.67±36.55
physical performance, kg-m/min	6-7	girls	295.97±4,26	310.37±2.69
		boys	306.92±1,28	315.07±1.39
	8-10	girls	363.76±15.52	426.76±27.86
		boys	380.39±19.27	460.90±45.78

There is a trend of decreased height of deaf children compared to their peers without hearing loss: for 6–7 – year-olds, the height of deaf girls was 111.85 ± 0.39 cm, boys – 112.63 ± 0.44 cm, while in children without hearing loss, these figures were 113.25 ± 1.09 cm and 114.00 ± 1.05 cm, respectively ($p > 0.05$). For 8–10 – year-olds, the height of deaf girls was 120.36 ± 0.61 cm, boys – 122.12 ± 0.44 cm; in children without hearing loss – 121.33 ± 1.14 cm and 124.17 ± 2.4 cm, respectively ($p > 0.05$). The body weight of girls aged 6–7 years old without hearing loss was 22.24 ± 0.44 kg, and 8–10 years old – 26.17 ± 0.64 kg, which is considered normal. Regarding the body weight of deaf girls, it differed significantly from the body weight of their normal-hearing peers ($p < 0.05$). Deaf girls 6–7-year-olds weighed 1.8 kg less ($p < 0.05$), which was 8.09%, and boys – 2.22 kg less ($p < 0.05$), which is 10.03 %. Deaf girls aged 8–10 years old weighed less by 3.01 kg ($p < 0.05$), which is 11.5 %, boys – 2.81 kg ($p < 0.05$), which is

10.79 %. Chest circumference in deaf girls 6–7 years old was lower than in children without hearing loss – 2.3 cm ($p < 0.05$), which is 4.08 %; in deaf boys, chest circumference was lower by 2.79 cm ($p < 0.05$), which is 4.93 %. At the age of 8–10 years old, the chest circumference of deaf girls was lower by 5.47 cm ($p < 0.05$), which is 8.57 %, and boys – by 6.02 cm ($p <0.05$), which is 9.29 %.

In deaf girls aged 6–7 years old, vital lung capacity was 1046.15 ± 24.29 ml, which is 125 ml less than their normal-hearing peers ($p < 0.05$), in deaf boys – 1200.00 ± 27.57 ml, which is 175 ml less than in boys without hearing loss ($p < 0.05$). In deaf children aged 8–10 years old, vital lung capacity values were significantly different from the results of their peers without hearing loss на 161.90 ml and 188.59 ml, respectively ($p < 0.05$).

A decrease in physical performance was found in deaf children compared to their normal-hearing peers for both age groups: girls – 295.97 ± 4.26 kg-m/min) ($p < 0.05$) and 310.37 ± 2.69 kg-m/min, respectively ($p < 0.05$); boys – 306.92 ± 1.28 kg-m/min and 315.07 ± 1.39 kg-m/min, respectively ($p < 0.05$).

The results of the study on physical performance of deaf children aged 8-10 years old were significantly different from the results of children without hearing loss ($p <0.05$).

Also, in solving the first task of the study to determine the complexity and nature of deaf children functional disorders in comparison with their peers without hearing impairments, the following was determined: resting hear rate in deaf girls and boys aged 6–7 years old tended to increase compared to their peers without hearing loss: in girls by 1.64 beats/min ($p > 0.05$), which is 1.78%, in deaf boys - by 10.46 beats/min ($p > 0.05$), which is 11.79%. In 8–10 – year-olds, the same trend was observed: the heart rate of deaf girls increased by 10.36 beats/min ($p > 0.05$), which is 14.59%, boys' heart rates increased by 17.8 beats/min ($p < 0.05$), which is 27.73%. Systolic and diastolic blood pressure values in deaf boys and girls was significantly different than the comparison group.

Table 2. *Electrocardiogram (Lead II) values of children aged 6–7 and 8–10 at rest*
Source: authors'own contribution

Indices of the electrocardiogram	Children aged 6–7		Children aged 8–10	
	normal hearing (n=16)	deaf (n=32)	normal hearing (n=12)	deaf (n=40)
P, mm	1.41±0.14	1.27±0.08	1.25±0.17	1.21±0.07
Q, mm	1.06±0.17	0.81±0.06	1.04±0.28	0.91±0.07
R, mm	12.5±1.07	12.41±0.85	13.67±1.64	12.03±0.73
S, mm	3.00±0.55	1.61±0.2	2.08±0.35	1.37±0.15
T, mm	2.81±0.36	3.16±0.2	3.25±0.28	3.08±0.2
P-Q, sec	0.14±0.01	0.14±0.004	0.14±0.01	0.14±0.003
QRS, sec	0.07±0.003	0.05±0.002	0.07±0.01	0.05±0.002
S-T, sec	0.12±0.01	0.11±0.004	0.14±0.01	0.12±0.01
Q-T, sec	0.31±0.01	0.34±0.01	0.34±0.003	0.37±0.01
QTc, %	50.78±1.75	55.27±1.1	44.15±0.8	47.42±1.27
R-R, sec	0.63±0.01	0.69±0.02	0.78±0.01	0.71±0.03

We found no significant differences in electrocardiogram values in normal-hearing children of both age groups (Table 2). In deaf children, automatism was not impaired, as evidenced by the correct sinus rhythm in all subjects. The amplitude of the P, Q and R waves in deaf children was slightly lower than in normal-hearing children, which indicates a decrease in total voltage on the electrocardiogram. Pathological changes of P, Q, R and S waves were found in deaf children - sharpening of the top of waves, and "double-humped" waves. Changes in the T wave and the duration of the S-T interval indicate possible disorders of metabolic and regenerative processes in the ventricular myocardium in deaf children. Analysis of the QRS complex of deaf children showed a trend towards delay in intraventricular conduction. In deaf children in both age groups, we observed a trend of prolonged electrical systole, which can be explained as a sign of Jervell and Lange-Nielsen syndrome, and repolarization abnormalities in the ventricular myocardium. An increase in QTc% by more than 5% suggests a dysfunction of myocardial contractility in deaf children.

Having analyzed the echocardiograms of normal-hearing and deaf children, we can conclude that their results did not differ significantly ($p > 0.05$). Only concomitant pathologies in deaf children, such as frequent sore throats and rheumatic heart disease, cause mitral valve prolapse because they damage the structure of the heart muscle. It is necessary to continue monitoring such children to prevent more serious heart problems.

Deaf children aged 6-7 years old had lower adrenaline excretion rates than normal-hearing children by 2.33 μg/day ($p < 0.05$), which is 54.19%, and noradrenaline excretion rates were 4.72 μg/day ($p < 0.05$), which is 43.3%. Among deaf children aged 8-10 years old, adrenaline excretion was lower by 4.42 μg/day ($p < 0.05$), which is 71.29%, and noradrenaline by 10.61 μg/day ($p < 0.05$), which is 64.7% (Fig. 1).

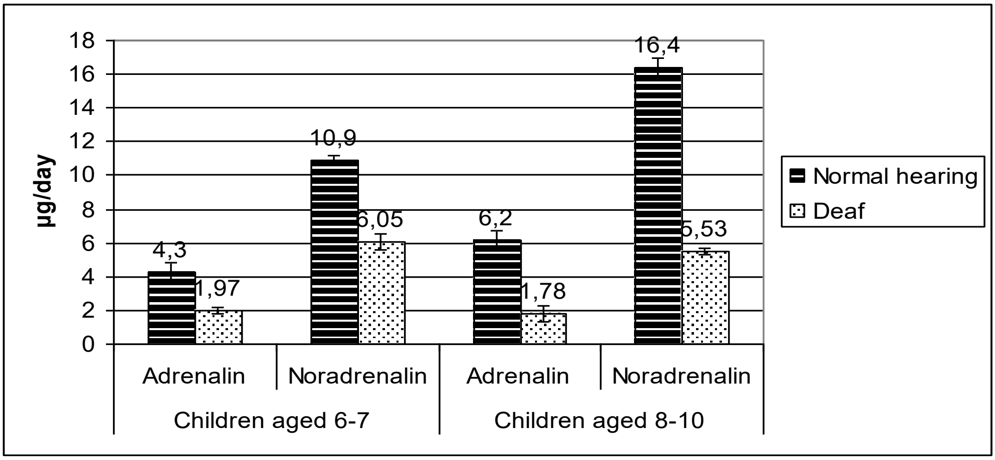

Fig.1. Indices for the excretion of adrenaline and noradrenaline in children aged 6-7 and 8-10
Source: authors'own contribution

Objective 2: ***The study of the physical condition of children with hearing deprivation revealed the peculiarities of their development, which in turn made it possible to differentiate the requirements for the gradual correction of the physical condition of deaf students, to systematize, regulate and detail the experimental Exercise Program. Exercise Program is based on specific principles: developmental training, correctional direction, and the principle of activity. The principle of developmental learning allows you to focus on the healthy strengths of the child, determining its individual capabilities. The principle of correctional direction was realized due to the individually differentiated approach to the child, considering the structure and severity of impairments, identifying the potential of each child.***

Corrective orientation is also manifested in the selection of means of physical education, which are aimed at overcoming the existing disorders of motor function in deaf children. The principle of developmental learning was considered when selecting games according to the age and children's state of health.

The basis of the program of the deaf junior schoolchildren physical condition correction are motor games of different intensity. Physically intensive games were divided according to their impact on heart rate: low intensity games are those where heart rate does not exceed 120 beats per minute; medium-intensity games are those where heart rate ranges from 120-140 beats per minute; high-intensity games are those where hear rate does not exceed 150 beats per minute.

Moving games are classified: by complexity and level of perception (moving games for preparatory, first, second and third grades), by nature of the impact on the body (games of general developmental and corrective influence). Games of general developmental influence are aimed at the development of strength, speed, agility, flexibility and endurance. Corrective games are aimed at improving the coordination of movements, their accuracy, balance, spatial orientation, reaction speed, attention, memory.

Physical games were divided by level of complexity and perception, physical intensity, and impact on the body – 64 corrective and 32 general development games. Corrective games were aimed towards improving the coordination of movements and their accuracy, balance, spatial orientation, reaction speed, concentration, and memory. General development games were aimed towards improving strength, speed, agility, flexibility, and endurance.

Objective 3: ***The experimental program was implemented in the educational process of special educational institutions to test its effectiveness and the possibility of further application. The effectiveness of the implementation of the proposed program was assessed by the dynamics of physical condition.***

We reexamined the children at the end of the pedagogical experiment and found significant positive changes in the studied values in deaf primary school-age children (Table 3).

There was a trend of increase in growth of deaf children aged 6-7 and 8-10 in both the control and experimental groups, which was slightly higher in the experimental group. Body weight of deaf children aged 6-7 years for the CG and EG did not differ significantly from the values in the comparison group. At the age of 8-10 years, the body weight of deaf children in the CG was significantly different from that of children in the comparison group, and in the EG this trend was not observed. Chest circumference values increased in both groups and were not significantly different than the comparison group ($p > 0.05$).

In deaf girls 6–7 years of age, vital lung capacity increased by 53.85 ml ($p > 0.05$), which is 5.15%, and in the EG there was a more significant increase of 160.99 ml ($p < 0.05$), which is 15.39%. For deaf boys in the CG of the same age, vitally lung capacity increased by 50 ml ($p > 0.05$), which is 4.17%, and in the EG by 180 ml ($p < 0.05$), which is 15%. In children aged 8–10 years in both the EG and the CG, there was an improvement in this value. Deaf girls in the CG of this age group, vital lung capacity increased by 103.57 ml ($p < 0.05$), which is 7.42%, and in the EG by 203.57 ml ($p < 0.05$), which is 14.58%. For deaf boys in the CG, vital lung capacity increased by 69.23 ml ($p < 0.05$), which is 4.7%, and in the EG by 169.23 ml ($p < 0.05$), which is 11.49%. For the 6-7-year-old group, there was a significant difference in vital lung capacity in deaf children and their normal-hearing peers, as well as between the CG and the EG. In children aged 8-10 years, there was a significant difference in vital lung capacity in both groups, as well as for deaf boys in the CG and the comparison group ($p < 0.05$).

In deaf girls 6–7 years of age in the CG, physical performance increased by 2.39 kg-m/min ($p > 0.05$), which is 0.81%, in the EG using the corrective program – by 21.17 kg-m/min ($p < 0.05$), which is 7.15%. In boys of the same age, the CG had the same trend: an increase in physical performance by 2.76 kg-m/min ($p > 0.05$), which is 0.9%, and the EG by 12.36 kg-m/min ($p < 0.05$), which is 4.03%.

Among deaf girls aged 8–10 years in the CG, there was an increase in physical performance by 3.18 kg-m/min ($p> 0.05$), which is0.87%, while in deaf girls in the EG the increase was 17.93 kg-m/min ($p < 0.05$), which is 4.93%. For boys in the CG, physical performance increased by 1.85 kg-m/min ($p > 0.05$), which is 0.49%, and in the EG by 33.58 kg-m/min ($p < 0.05$), which is 8.83%.

Table 3. Indices of physical state of the deaf junior schoolchildren after implementing the Exercise Program
Source: authors'own contribution

Indices	Children aged	Sex	deaf children CG (n=35)	deaf children EG (n=37)

the height, cm	6-7	girls	113.33±0.56	113.71±0.36
		boys	113.8±0.75	114.3±0.58
	8-10	girls	121.32±0.52	122.71±0.88
		boys	123.08±0.96	123.62±0.84
the body weight, kg	6-7	girls	21.78±2.39	22.27±1.46
		boys	21.11±1.58	22.47±1.51
	8-10	girls	24.30±0.36	24.90±0.96
		boys	23.85±0.85	24.30±0.75
chest circumference, cm	**6-7**	girls	55.83±0.23	56.57±0.33
		boys	55.60±0.69	56.11±0.38
	8-10	girls	60.14±0.47	61.45±0.52
		boys	60.54±0.68	61.38±0.84
vital lung capacity, ml	6-7	girls	1100.00±12.14	1207.14±12.33
		boys	1250.00±10.18	1380.00±11.29
	8-10	girls	1500.00±12.66	1600.00±12.47
		boys	1542.31±13.85	1642.31±11.65
physical performance, kg-m/min	6-7	girls	298.36±14.12	317.14±10.23
		boys	309.68±13.69	319.23±12.34
	8-10	girls	366.94±12. 88	381.69±12.55
		boys	382.24±11.86	413.97±11.23

In the 6–7 – year-old age group, the physical performance of children in the EG was significantly different than for children in the CG and the comparison group. In 8–10 – year-old deaf children, in addition to significant differences from the CG, differences were found compared with normal-hearing children.

The resting heart rate of deaf girls aged 6–7 years in both groups did not differ significantly from the initial values ($p > 0.05$). In deaf boys of the same age in the CG, there were no significant changes in this value ($p > 0.05$), while in the EG the results were significantly different from the initial values ($p < 0.05$). Among deaf children aged 8-10 years in the CG and EG, there were no significant changes in heart rate compared to baseline values ($p > 0.05$). Both systolic and diastolic blood pressure values were higher in the EG than the CG ($p < 0.05$).

Electrocardiogram analysis (Table 4) suggests that the duration of the QRS complex indicates a delay of intraventricular conduction in deaf children. The duration of the S-T interval indicates a decrease in metabolic and regenerative processes in the ventricular myocardium in deaf children who followed the Exercise Program.

Table 4. Electrocardiogram (Lead II) values of children aged 6-7 and 8-10 at rest after following the Exercise Program
Source: authors'own contribution

Indices of electrocardiogram	Children aged 6-7			Children aged 8-10		
	normal hearing (n=16)	deaf CG (n=15)	deaf EG (n=17)	normal hearing (n=12)	deaf CG (n=20)	deaf EG (n=20)
P, mm	1.41±0.14	1.60±0.19	1.15±0.10	1.25±0.17	1.45±0.21	1.18±0.12
Q, mm	1.06±0.17	1.13±0.24	1.03±0.23	1.04±0.28	0.90±0.13	1.13±0.17
R, mm	12.5±1.07	12.87±1.02	12.00±1.13	13.67±1.64	12.70±1.14	13.85±0.98
S, mm	3.00±0.55	1.47±0.27	2.41±0.41	2.08±0.35	2.23±0.33	1.88±0.29
T, mm	2.81±0.36	2.77±0.34	2.71±0.33	3.25±0.28	3.75±0.38	2.80±0.23
P-Q, sec	0.14±0.01	0.13±0.01	0.13±0.01	0.14±0.01	0.14±0.004	0.12±0.004
QRS, sec	0.07±0.003	0.07±0.003	0.07±0.002	0.07±0.01	0.07±0.002	0.07±0.002
S-T, sec	0.12±0.01	0.13±0.01	0.12±0.01	0.14±0.01	0.13±0.004	0.13±0.004
Q-T, sec	0.31±0.01	0.35±0.01	0.31±0.002	0.34±0.003	0.36±0.004	0.33±0.004
QTc, %	50.78±1.75	53.83±1.42	47.05±1.34	44.15±0.8	48.33±1.25	42.88±0.89
R-R, sec	0.63±0.01	0.65±0.03	0.68±0.02	0.78±0.01	0.76±0.02	0.78±0.02

As a result of following the Exercise Program, adrenaline excretion levels increased in deaf children 6-7 years old in the EG by 0.7 μg/day ($p < 0.05$), which is 35.53%, and in the CG by 0.16 μg/day ($p > 0.05$), which is 8.12%. Adrenaline excretion levels in deaf children aged 8-10 years in the CG increased by 0.38 μg/day ($p > 0.05$), which is 21.35%, and in the EG by 0.97 μg/day ($p < 0.05$), which is 54.49%. In relation to the amount of noradrenaline excretion, we obtained the following values: in deaf children aged 6-7 years in the CG, it increased by 0.95 μg/day ($p > 0.05$), which is 15.37%, and in the EG by 2.81 μg/day ($p < 0.05$), which is 45.47%. In deaf children aged 8-10 years in the CG, noradrenaline excretion increased by 0.63 μg/day ($p > 0.05$), which is 11.27%, in the EG by 2.53 μg/day (p < 0, 05), which is 45.26%. The results are better than the baseline values, however, they did not reach the values of normal-hearing children.

Discussion

It has been established that hearing loss negatively affects the physical development of primary school-age children. It was determined that deaf children have a lower height than their peers without hearing loss ($p > 0.05$). Body weight and chest circumference of deaf children significantly differ from those of their peers without hearing loss ($p < 0.05$), which is confirmed by Graf et al. (2004). The consequences of insufficient physical development of deaf primary school-age children are postural defects. Thus, among 6 and 7-year-old deaf children, scoliotic (asymmetric) posture was found in 18.75%, slouching in 15.63%, flat back in 9.38%, flat feet in 59.38%. Among 8-10-year-old deaf children, the disorders were found in 12.5%, 25%, 7.5% and 52.5%, respectively. This can be illustrated by citing two studies – Rajendran & Roy (2011) and Melo (2017a, 2017b) concluded that hearing loss affects the vestibular system and body awareness.

Deafness affects the functional state of the respiratory system. An underdeveloped vocal apparatus in deaf children causes a delay in the development of the lungs and respiratory tract. This is due to a decrease in chest mobility as a result of physical deconditioning. Deaf primary school-age children showed a significant decrease in physical performance ($p < 0.05$) compared to normal-hearing peers according to the results of the PWC_{150} test. We found that all spirometric indices tended to be lower in deaf children, in all age groups studied and irrespective of gender, compared with their normal-hearing peers. The results of Zebrowska & Zwierzchowska (2006), demonstrate that sensory deprivation of deaf children affects the functional capabilities of the respiratory system.

There is no information in the scientific and technical literature about the distribution of values of electrocardiography, echocardiography or the sympathoadrenal system in the studied age group of children by gender. This allowed us to study values for both boys and girls. It was determined that deaf children have respiratory arrhythmia due to increased vagal innervation, but this is not considered pathological. There was also a trend of increased heart rate compared to normal-hearing peers. Both systolic and diastolic blood pressure values were significantly lower in deaf children compared to their normal-hearing peers. Research by Veena et al. (2015) showed the same results.

Electrocardiography values of children without hearing loss are within the normal range for their age. According to echocardiography results, no significant differences were found in deaf children or their peers, which is likely due to hearing loss not having an effect on morpho-functional parameters of the heart. However, Motasaddi Zarandy et al. (2016) believe that large-scale echocardiographic studies comparing children of the same age group with and without hearing loss are required to determine the prevalence of heart defects.

There was no significant difference between values of the sympathoadrenal system of normal-hearing children and the normal ranges of values. Deafness negatively affects the state of the sympathoadrenal system and this causes a decrease in adrenaline and noradrenaline, which are neurotransmitters. Low levels of catecholamines negatively affect the processes of physical and social adaptation of children.

The results of evaluating the effectiveness of the program for the correction of deaf primary school-age children's physical conditions suggest that the Exercise Program has a positive impact on body awareness and wrist dynamometry. The physical performance of deaf children in the experimental group increased compared to the control group, but did not reach the level of their peers without hearing loss. The Exercise Program showed positive changes ($p < 0.05$) in the physiological mechanisms of exercise on the respiratory, cardiovascular and sympathoadrenal systems of deaf primary school-age children. There were significant changes in vital lung capacity in deaf children - reaching the levels of their normal-hearing peers. The results also revealed a significant improvement of contractility, repolarization, metabolic and regenerative processes in the ventricular myocardium in deaf children. Children following the Exercise Program had a significant increase in the excretion of adrenaline and noradrenalin: for 6–7-year-olds, the amount of adrenaline excretion increased by 0.7 μg/day, noradrenaline by 2.81 μg/day and for 8–10-year-olds, 0.97 μg/day and 2.53 μg/day, respectively) – values close to those of children without hearing loss. These shifts in the sympathoadrenal system of deaf children indicate an improvement in their physical condition.

Thus, the obtained results allow us to assert the experimental validity of the effectiveness of the Exercise Program for the correction of the deaf primary school aged children physical condition, which is based on motor games of different direction and intensity. This determines the pedagogical value of the developed program of correctional direction in special educational institutions for deaf children.

Conclusion

The results of anthropometric measurements revealed lower height, weight and chest circumference in deaf primary school-age children compared to their peers without hearing loss. It was found that the physical performance of deaf children is lower than the performance of schoolchildren without hearing loss, but when converting the values to per kilogram of body weight, the differences were less pronounced. Deaf children showed significantly weaker perception of self-movement.

It was established that the state of the cardiovascular system of deaf children according to electrocardiography is characterized by disorders of the metabolic and regenerative processes in the ventricular myocardium; intraventricular conduction delay; prolonged electrical systole, repolarization abnormalities in the ventricular myocardium; myocardial contractility abnormalities. According to echocardiography, no significant differences were found in deaf and normal-hearing children, which means that deafness likely does not affect the morpho-functional parameters of the heart. Excretion of adrenaline and noradrenaline is 2-3 times lower in deaf children than in normal-hearing children. In turn, this causes slow, uncoordinated movements and leads to reduced physical performance according to the results of the physical work capacity (PWC_{150}) test.

The effectiveness of the program based on physical games was demonstrated for correcting the physical condition of deaf primary school-age children, measured by the children's physical development, respiratory, cardiovascular and sympathoadrenal systems: trend of improvements in posture, gait, self-esteem; significant changes occurred in vital lung capacity; significant improvement in contractility, repolarization, metabolic and regenerative processes in the ventricular myocardium; significant increase in the excretion of adrenaline and noradrenaline to values close to those of normal hearing children.

Competing Interests. The authors declare that they have no competing interests.

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