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Original Article

Evaluation of the physiological characteristics of girls with different handedness using various types of physical training

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Abstract: We evaluated the effectiveness of various types of physical training during classes of 5–6-year-old girls with different handedness. Each training method was applied to girls with ambidexterity, left- and right-handedness, who were between 5 years of age and 5 years 5 months and 29 days old. A total of 135 girls participated in the study. Specifically, 60 girls were part of the intervention group (20 girls with ambidexterity, 20 - with left-handedness, and 20 - with right-handedness), and the other 75 girls were part of the control group (25 girls with each type of handedness). We used well-known functional tests recommended by the researchers. Physiological characteristics are related to the activity of the cardiovascular, respiratory, and neuromuscular systems. The criterion showed significant improvement in the accuracy of the value of each of the studied functional parameters. It was established that the experimental factor provides better results for girls with existing handedness than the traditional approach. The performance was improved, and the final scores were significantly higher than those in the groups of girls who used a traditional approach of implementing the contents of physical training. The features of functional change in girls with different handedness and the final results need further investigation. However, in the three intervention groups, the experimental factor resulted in better values of all parameters than those used in the control group, which used a traditional approach of implementing the contents of physical training. The number of indicators changed considerably in size (not including blood pressure). The results (i.e., all six indicators) of the intervention groups improved. The control group showed improvement only in four of these indicators.
Keywords: girls, preschool age, handedness, experimental physical education content.

Introduction

The main function of a child during the preschool period is to move. Physical education is the best tool, which provides sufficient motor activity and development functionality for these children (Malina, Bouchard, 2004; Schmidt, Lee, 2013; Kalinková, 2007; Motow-Czyż, Orczyk, 2014). Currently, these activities do not allow 6-year old children to achieve a high level of functionality (Iedynak, 2011; Galamandjuk, Balatska, 2014). Therefore, social, psychological, and physical adaptation of children to the new environment in school are inadequate. This is manifested as the deterioration of health and functional capacity (Bergier, Tsos, Bergier, 2014; Altavilla, Di Tore, 2016) and mental fatigue (Herasymchuk, Galamandjuk, Iedynak, 2014). This is attributed to the lack of innovative approaches and, methods (options) of organization, development, and implementation of the contents of physical training sessions (Buns, 2015; Di Tore, Schiavo, D'isanto, 2016).

Materials and methods

To study the functional capabilities of children, common indicators were measured such as the heart rate at rest, after dosed physical activity, and during leisure (the Ruffier-Dickson test), blood pressure, vital capacity (VC), and dynamometry. The latter was used to determine the index of maximum isometric strength (IMIS = maximum isometric strength / body mass). We used certified equipment: to determine the blood pressure - Santamedical Adult Deluxe Aneroid Sphygmomanometer; to determine the IMIS - handgrip Camry dynamometer; to determine the VC - NDD EasyOne Plus System 2000-2 spirometer. Prior to the study, we obtained the permission to participate in the study from each girl and her parents. The experiment lasted for one

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academic year. The study involved 135 girls between five and six years of age: 60 girls [20 with ambidexterity (A), 20 with left- (L) and 20 with right-handedness (R)] were part of the intervention group (IG), and the other 75 girls (25 girls with each type of handedness) were part of the control group (CG). The research was conducted in compliance with the WMA Declaration of Helsinki, Ethical Principles for Medical Research Involving Human Subjects, 2013. The study protocol was approved by the Ethical Committee of Kamianets-Podilskyi National Ivan Ohiienko University. The handedness of the girls was determined at baseline using a Short Form of Edinburgh Handedness Scale (Veale, 2014). The indicators were examined twice (i.e., at the beginning of the experiment in September and then again in April), and the obtained IG and CG data were compared with each other. The difference in the experimental factors was the physical training lessons at the preschool educational institution. 1) CG girls learned traditional basic movements, which were performed with a dominant arm (leg) in a dominant direction. The IG used a symmetric approach: each movement was first performed with a non-dominant arm (leg) in a non-dominant direction, and then repeated by the dominant arm (leg). Thus, the performance of motion by a non-dominant arm (leg) in a non-dominant direction does not imply mastering that motion at the highest level (capitalization of degrees of freedom - CDF; and exploration of degrees of freedom - EDF) (Bernstein, 1991). Attention was focused on the main elements of the movement technique. The main focus was on the ability to reproduce the movement with maximum accuracy. Then, the same movement was performed with the dominant arm (leg) but at the highest level (CDF). Simultaneously, the children continued to perform the motion first with a dominant arm (leg) and then with a non-dominant arm (leg). The aim was to repeat the movement. 2) For the CG, special exercises were used to develop flexibility, speed, and different types of coordination. The IG girls did not perform deliberate exercises; these exercises were performed indirectly through games to reach their respective EDF and CDF. In addition, the IG girls used affirmations and breathing exercises, with emphasis on relaxation and revitalization, which the CG girls did not perform. 3) For the IG, all activities were provided for a specific day of the week, including aerobic activities; the CG girls were not provided with such activities. 4) For the teachers, a seminar was conducted to form and implement their practical knowledge and to provide consultations, if necessary. 5) Using the abovementioned information, the instructors of physical education and teachers emphasised to the girls' parents the need to perform physical activities at home.

All statistical analyses were performed using SPSS Version 21. The results of descriptive statistics in this study were presented as the means, standard deviations, and percentages. The data were normally distributed. An independent t-test was used to compare the achievements of the IG and CG girls of a certain handedness. The 0.05, 0.01, and 0.001 levels of probability were used to indicate statistical significance (Vincent, 2005).

Results

At the beginning of the experiment, it was determined that the studied parameters for the IG and CG of girls of each type of handedness were similar (Table 1). However, the final results were considerably different.

Table 1. Changes in functional and physical performance in A-handed girls during the experiment (IG: n=20, CG: n=25)

Indicator	Group	Initial		Final		Difference		t	
		M_1	SD	M_2	SD	absolute unity	%	$M_1 - M_2$	$M_2 - M_2$ (IG – CG)
Heart rate in rest, bpm	IG	97.7	1.4	90.1	1.1	-7.6	7.8	4.27***	4.12 ***
	CG	97.6	1.3	96.8	1.2	-0.8	0.8	0.45	
Heart rate after activity, bpm	IG	166.7	2.5	146.5	1.1	-20.2	12.1	7.4***	2.97 **
	CG	165.1	2.9	154.6	2.5	-10.5	6.4	2.74*	
Heart rate on 45th second of rest, bpm	IG	139.8	2.1	123.1	2.2	-16.7	11.9	5.49***	2.83 *
	CG	139.1	2.0	131.7	2.1	-7.4	5.3	2.55*	
Systolic blood pressure, mm Hg	IG	98.8	1.8	101.1	1.9	2.3	2.3	0.88	2.28 *
	CG	102.3	1.5	106.1	1.1	3.8	3.7	2.04	
Diastolic blood pressure, mm HG	IG	57.3	2.1	60.2	2.4	2.9	5.1	0.91	4.56 ***
	CG	64.1	2.4	73.1	1.5	9.0	14.0	3.18**	
VC, ml	IG	1108	18.2	1240	15.7	132.0	11.9	5.49***	3.09 **
	CG	1100	24.3	1170	16.3	70.0	6.4	2.39*	
IMIS, %	IG	48.1	2.3	53.7	1.2	5.6	11.6	2.16*	2.31 *
	CG	46.2	1.7	48.7	1.8	2.5	5.4	1.01	
Ruffier-Dickson Index (RDI), c.u.	IG	20.42	0.7	15.97	0.5	-4.5	21.8	5.17***	3.0 **
	CG	20.18	0.6	18.31	0.6	-1.9	9.3	2.2*	

Note: * p <0.05, **p <0.01, *** p <0.001

Thus, girls with A-handedness exhibited the most significant change in the value of improved IG heart rate at rest, while that in the CG - remained the same; the RDI values showed a similar trend in the change of neuromuscular system. Systolic and diastolic blood pressures changed in both the IG and CG, –although the degree of change was considerably different; however, the final values were within the age norms (Malina, Bouchard, Bar-Or, 2004). The development of the respiratory system and increase in physical performance were also characteristic for both groups, but the IG showed a significantly higher value than that of the CG. Therefore, based on the positive trend in blood pressure, it is determined that the content of physical training used for the A-handed IG girls resulted in the improvement of all studied parameters, while that used in the CG resulted in the improvement of only 6 parameters. In addition, the content of physical training used in the IG resulted in higher values of all eight indicators than those in the CG. A similar result was obtained in the experimental groups of girls with R-handedness, excluding the change in the studied functional performance and physical performance. Thus, based on the importance level (from $p < 0.05$ to $p < 0.001$), the IG and CG improved their cardiovascular system at rest and after stress during the holidays. However, in all cases, the IG girls shower better improvement than that of the CG girls (Table 2). A similar change was also an expression of physical performance at the end of the

Table 2. Changes in functional performance and physical performance in R-handed girls during the experiment (IG: n=20, CG: n=25)

Indicators	Group	Initial		Final		Difference		t	
		M_1	SD	M_2	SD	absolute unity	%	$M_1 – M_2$	$M_2 – M_2$ (IG – CG)
Heart rate in rest, bpm	IG	100.4	2.0	91.2	1.9	-9.2	9.2	3.33**	2.82
	CG	100.2	1.9	98.4	1.7	-1.8	1.8	0.71	*
Heart rate after activity, bpm	IG	165.1	2.1	145.7	2.6	-19.4	11.8	5.8***	2.38
	CG	166.4	2.4	154.3	2.5	-12.1	7.3	3.49**	*
Heart rate on 45th second of rest, bpm	IG	139.1	2.2	122.8	1.9	-16.3	11.7	5.61***	2.55
	CG	138.2	2.6	130.4	2.3	-7.8	5.6	2.25*	*
Systolic blood pressure, mm Hg	IG	99.6	2.7	98.1	1.7	-1.5	1.5	0.47	3.95
	CG	101.4	2.5	105.9	1.0	4.5	4.4	1.67	***
Diastolic blood pressure, mm HG	IG	60.5	2.8	60.1	1.9	-0.4	0.7	0.12	4.71
	CG	66.7	1.9	72.1	1.7	5.4	8.1	2.12*	***
VC, ml	IG	1110	19.7	1260	14.1	150.0	13.5	6.19***	3.31
	CG	1130	21.5	1190	15.8	60.0	5.3	2.25*	**
IMIS, %	IG	47.1	2.1	54.8	2.1	7.7	16.3	2.59*	2.09
	CG	46.2	1.9	48.6	2.1	2.4	5.2	0.85	*
Ruffier-Dickson Index (RDI), c.u.	IG	20.46	0.07	15.97	0.5	-4.5	21.9	8.89***	3.0
	CG	20.48	0.06	18.31	0.6	-2.2	10.6	3.6**	**

Note: * $p < 0.05$, **$p < 0.01$, *** $p < 0.001$

experiment (RDI), the state of functioning of the respiratory (VC) and neuromuscular (IMIS) systems of girls with R-handedness. Thus, at the end of the experiment, the girls in the IG achieved significantly better values than those of the CG girls.

The results of L-handed girls differed from those above. Specifically, for the IG, there was an improvement in the heart rate at rest, while it remained the same for the CG; however, the change in values is not a reliable indicator (Table 3). A similar change was observed for the IMIS, which describes the state of functioning of the neuromuscular system, excluding value gains in the IG and CG.

The values of other indicators showed the development of appropriate functionality in these research groups. However, in each case, a change in the IG was more prominent than that in the CG. Thus, at the end of the experiment, the values of all 8 IG studied parameters were significantly better compared with those in the CG.

Discussion

The results in the IG and CG of girls with different handedness are attributed to various reasons. In general, the best results were obtained using the IG content of physical training. This is demonstrated by the results of girls with A-, R-, and L-handedness. Nevertheless, all forms of physical training used provided aerobic activity for children. The aerobic energy mechanism is essential (Bar-Or, 2004).

Table 3. Changes in functional performance and physical performance in L-handed girls during the experiment (IG: n=20, CG: n=25)

Indicators	Group	Initial		Final		Difference		t	
		M_1	SD	M_2	SD	absolute unity	%	$M_1 - M_2$	$M_2 - M_2$ (IG – CG)
Heart rate in rest, bpm	IG	101.8	2.5	91.6	2.1	-10.2	10.0	3.12**	3.03
	CG	102.3	2.7	99.8	1.7	-2.5	2.4	0.78	**
Heart rate after activity, bpm	IG	166.7	2.6	144.8	2.2	-21.9	13.1	6.43***	2.86
	CG	167.1	2.1	154.1	2.4	-13.0	7.8	4.08***	*
Heart rate on 45th second of rest, bpm	IG	138.7	2.3	122.1	2.1	-16.6	12.0	5.33***	2.47
	CG	139.2	2.6	129.1	1.9	-10.1	7.3	3.14**	*
Systolic blood pressure, mm Hg	IG	98.7	1.9	98.1	1.8	-0.6	0.6	0.23	3.47
	CG	101.8	2.1	105.6	1.2	3.8	3.7	1.57	**
Diastolic blood pressure, mm HG	IG	60.1	2.5	61.1	2.3	1.0	1.7	0.29	3.32
	CG	67.1	1.9	70.6	1.7	3.5	5.2	1.37	**
VC, ml	IG	1105	21.1	1270	15.1	165.0	14.9	6.36***	2.83
	CG	1115	19.8	1210	14.9	95.0	8.5	3.83**	*
IMIS, %	IG	47.3	1.9	54.9	2.2	7.6	16.1	2.61*	2.17
	CG	46.9	1.8	48.6	1.9	1.7	3.6	0.65	*
Ruffier-Dickson Index (RDI), c.u.	IG	20.72	1.0	15.85	0.9	-4.9	23.5	3.62**	2.15
	CG	20.86	1.0	18.3	0.7	-2.6	12.3	2.1*	*

Note: * p <0.05, **p <0.01, *** p <0.001

It contributed more significantly to neuromuscular, respiratory, and cardiovascular improvement than the contents of physical education (CG) from different systems for girls with different handedness. This result confirms the conclusion of a previous study on the physical state of 4-6-year-old boys with different handedness (Galamandjuk, Iedynak, 2016), specifically on the effectiveness of the used experimental factor on the development of neuromuscular, respiratory, and cardiovascular systems.

To achieve positive results, it was essential to increase the knowledge of teachers about physical activities. Relevant information was provided during a methodological seminar, which was carried out to improve the quality of classes under the guidance of these teachers as well as the content of physical activities for children. The use of such activities by educators improves the quality of their life (Brodáni, Žišková, 2015). Thus, they are more likely to serve as examples to encourage children to perform various physical activities. Therefore, personal example is an important teaching technique, which ensures high positive results (Schmidt, Lee, 2013; Galamandjuk, Balatska, Iedynak, 2014; Buns, 2015; Di Tore, Schiavo, D'isanto, 2016).

Another reason why the observed results were obtained is the proposed interaction between educators and parents. This interaction resulted in parents understating the necessity for physical activities of their child at home and the practical implementation of these recommendations. Previous studies (Herasymchuk, Galamandjuk, 2014; Iedynak, & Mazur, 2017), which studied 4–6-year-old children with different handedness, showed that parents were engaged in physical activities at home in their spare time. At the same time, the result was obtained due to the use of IG symmetrical approach for learning basic movements. The implementation of coordinated movements of left and right hands increases the interaction between both hemispheres of the brain. This approach provides increased activity and successful education for A-hand children, and especially for R- and L-handed children (Shabbott, Sainburg, 2008; Galamandjuk, 2014; Gąsiewski, 2017). Physical activity improves different functions, skills, systems, which is especially important during pre-school (Altavilla, Di Tore, 2016). The performance of different movements by both dominant and non-dominant hands positively effects the motor functions of children.

Further studies are necessary to evaluate the features of functional change and final results obtained for girls with different handedness. However, in general, we observed that IG girls achieved considerably better values for all parameters than the CG girls, who used a traditional approach of implementing the contents of physical training. The number of indicators and their values changed significantly (excluding blood pressure). The results for all IG girls was the same. Specifically, six indicators improved. For the CG, only four indicators improved.

Conclusions

The use of experimental factor allowed girls with different handedness to achieve significantly higher results in the development of functionality than using the traditional approach to implementing the contents of physical training. The IG group, regardless of the handedness, improved performance and reached significantly higher final values than those of the CG girls.

Conflicts of interest

There are no conflicts of interest. The studies were performed at our own expense. No grants were used.

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