Physiological component of graph-motor skills of children aged from 5 to 8 years old

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Abstract

Introduction: The purpose of the work was to investigate the features of the physiological component of graph-motor skills of children aged from 5 to 8 years old. *Materials and methods:* Pupils of the 1st and 2nd grades (6-8 years old) and preschool children (5 years old) from general and pre-school educational institutions of Sumy city took part in the research. Hygienic, psychophysical, physiological methods and methods of mathematical statistics were used. *Results:* The assessment of physical development showed that 52.8±1.9% of children have a harmonious development, among them boys are over (58.3±2.7%) the group of girls (46.6±2.8%). Individual analysis of anthropometric indicators allowed to allocate among the surveyed children's contingent a "risk" group which includes individuals with excess body weight or its deficit. Endogenous factors influencing the formation of graph-motor skills are determined: physiological, cognitive and personal readiness. *Conclusions:* Mechanisms of physiological adaptation play an important role in adaptation of the child to the new conditions of the educational process, knowledge of their peculiarities is necessary for the early detection of minimal deviations of their health and the timely application of corrective measures.

Keywords: children, graph-motor skills, physical development, readiness for school.
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INTRODUCTION

It is common knowledge that children are characterized by increased sensitivity to the effects of various environmental factors, caused by intensive growth and maturation processes at junior school age. The functional readiness of the child to the new conditions for her schooling is one of the most urgent problem, since the education of Ukraine underwent changes [1-3].

Readiness for school is a factor of stress in each child's life. At this stage, the amount of information that the child perceives significantly increases, and also there is a dramatic change in occupation and rest. Therefore, the problem of children's readiness for school ("school maturity") attracts more and more attention of doctors and educators [2,4,5].

Special attention should be paid to the state of health of the children's population, among which there is a tendency to increase the number of children of the junior school age of the second and third groups of health. These children have increase in emotional and psychological stress, violation of the course of adaptive processes, leading to adaptive "breaks" and maladaptation. As a result of these reasons, in the child's body there are pathological changes of a different nature, which can lead to the formation of chronic diseases and functional disorders in the future. In this regard, the priority task of the modern school is the development of a comprehensive system of measures aimed to optimizing the educational process with the focus on preserving and strengthening the health of the younger generation [6,7].

When a child enters to an educational institution, there is a need to adapt to new conditions of life, to the conditions of education and the new regime. In studies on age-related physiology, this the one of the main problem of adapting of children and adolescents to school and physical activity. The process of adaptation depends not only on the individual characteristics of the body, but also on the state of health, age-related anatomical and physiological characteristics of the child. During the adaptation there is a decrease in the physiological reactivity of the organism, based on which there are the physiological mechanisms that provide child protection [8,9].

According to Bezrukyh and Farber readiness for school reflects the level of morphofunctional, functional and mental development of child's organism, a component of which is the graphic readiness of the child [4]. Graphic readiness is defined as a certain level of morphofunctional and mental development of the child when the systematic execution of graphic assignments at the initial stage of schooling does not lead to violations of the child's mental and physical health and ensures the success of school education. Theoretical generalization of the concept of "graph-motor skills" was carried out on the basis of the psychophysiological research of Ukrainian and foreign scientists. Graph-motor skills are the complex hierarchical self-regulating structure that reflects motor actions due to a thin differentiated sensitivity, adequate motor imagination, memory that provides effective control of movements and motor actions on the basis of exact self-control and self-regulation [4,7,10-15].

The aim of this study is to investigate the features of the physiological component of graph-motor skills of children aged from 5 to 8 years old.

MATERIALS AND METHODS

The use of all research methods was agreed with the administration of educational institutions, psychologists, educators and teachers. Written permission of the parents for the participation of their children in studywas obtained. Only children with a working right hand were involved in the research. There were 629 participants gathered – 296 girls and 333 boys with mean age of 6.5 years.

Anthropometric examination of children was performed by standard instruments according to the known unified method: body length was measured by anauxanometer; chest circumference withmeasure tape; body weight was determined with medical scales. The conclusion on the harmony of physical development was based in the compliance with the obtained anthropometric indicators with regional standards for assessing the physical development of children [16]. Functional state of the hand strength was studied by dynamometry using a dynamometer.

Statistical processing of the data was carried out on a computer using the standard STATISTICA 7.0 programs.

With the help of the method of collective expertise there was developed method for the integrated assessment of GMS of children aged from 5 to 8 years old.

Integral assessment (IS) of grammatical skills of children's writing:

$$IS = \frac{x_1 w_1 + x_2 w_2 + \ldots + x_i w_i + \ldots + x_n w_n}{w_1 + w_2 + \ldots + w_i + \ldots + w_n},$$

$x_1, x_2 \ldots x_n$ - score in points of defined indicators; $w_1, w_2 \ldots w_n$ - weight factors of indicators.

The leading components of the GMS of children are the following characteristics: "coordination capabilities" (14.39%), "stress during the writing" (11.25%) and "calligraphy" (30.95) [17].

RESULTS

A comparative analysis of children's division by sexual characteristics with different levels of graph-motor skills (GMS) showed that among the group of subjects with a high level of GMS, harmonic physical development PD was found in 57.9±0.4% of girls and in 64.2±0.5% of boys. At the same time, children with disharmonious PD with insufficient body weight have the lowest indices of this level of GMS (14.1±0.3% and 16.4±0.4% respectively) (Figures 1 and 2). In addition, it should be mentioned that girls with disharmonious PD with excess body weight have 8.7% higher level of GMS than boys.

The group of girls with an average level of GMS by 54.7±0.4% was formed due to disharmony of PD and 45.3±0.4% due to harmonic PD. While in the group of boys with a mean level of GMS, the proportion of children with harmonious PD by 18.4% prevails over the proportion of children with disharmonious PD. At the same time among children with disharmonious PD the proportion of those surveyed with excess body weight (28.2±0.3%) was higher than the proportion of children with insufficient body weight (12.6±0.2%). It should be noted that the low level of GMS in both girls and boys is characterized by the advantage disharmonious PD (60.3±0.3% and 51.7±0.4% respectively).

The distribution of children of different ages by the levels of GMS and the harmony of the PD allowed to establish the dominance of disharmonious PD due to excess body weight of children 5 years old in the groups of low (58.3±0.3%, p <0.001) and mean (56.5±0.3%, p<0.001) levels of GMS. This age group does not have high level of GMS (Table 1).
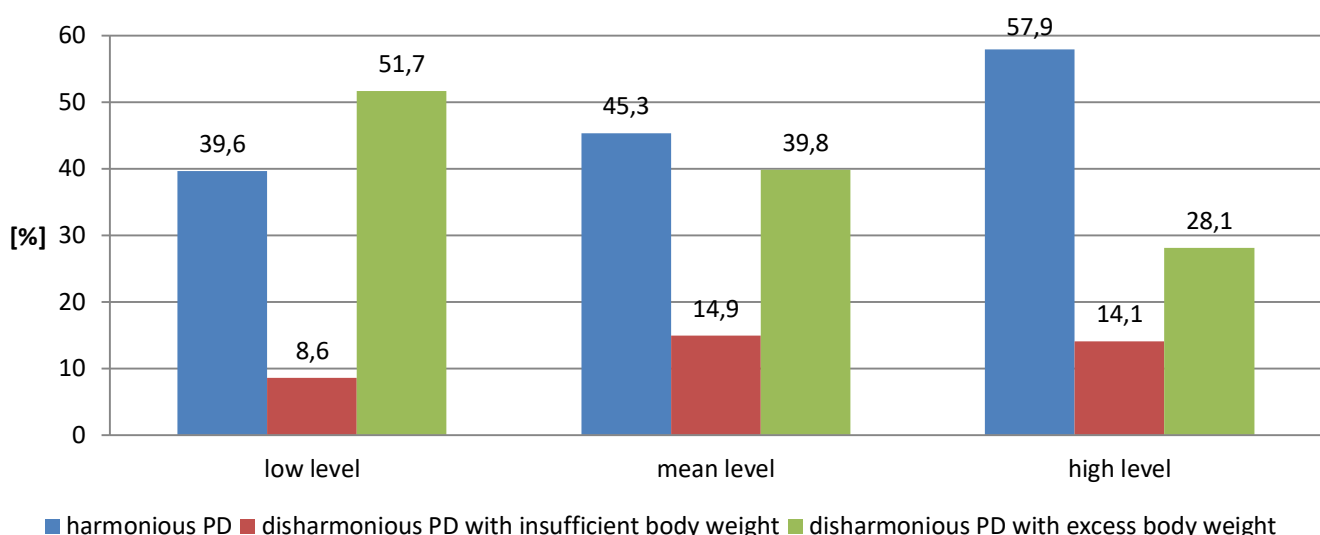

Figure 1. Distribution of girls aged from 5 to 8 with different levels of formation of graph-motor skills by levels of physical development (%)
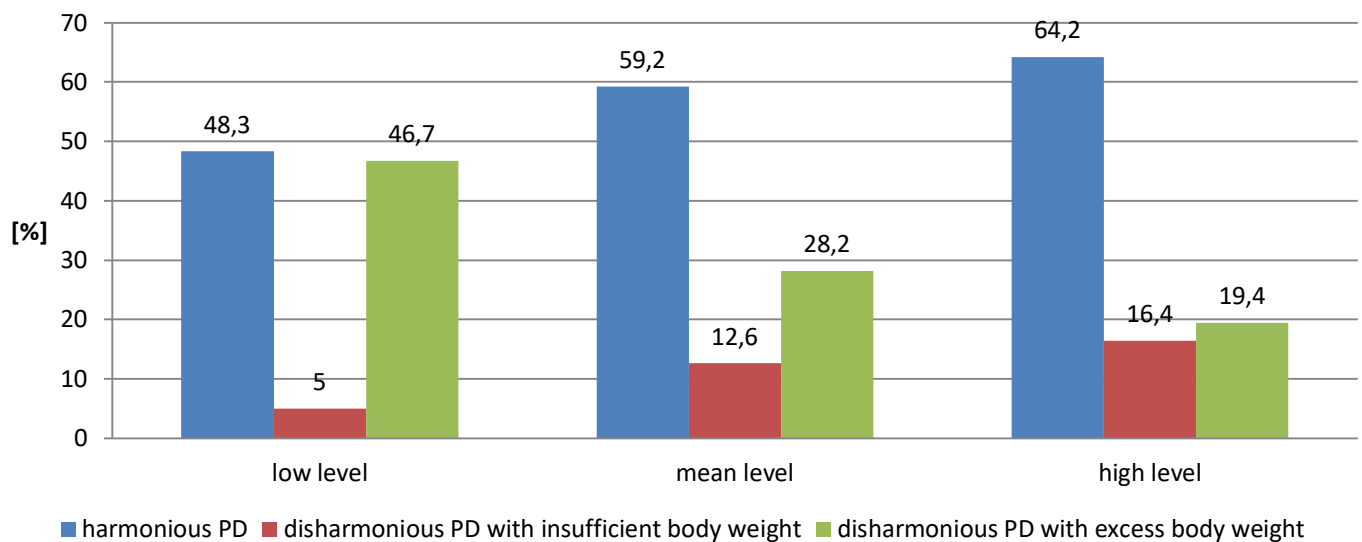
Figure 2. Distribution of boys from 5 to 8 years old with different levels of formation of graph-motor skills by levels of physical development (%).

Table 1. Distribution of children aged from 5 to 8 years old by levels of graph-motor skills and the harmony of physical development, M+SD [%]

Age	Levelof GMS	Harmony of PD		
		Harmonious	disharmonious PD with insufficient body weigh	disharmonious PD with excess body weight
5 years	Low (n=48)	33.3±0.2	8.3±0.1	58.3±0.3* ($t_{3.5}$=83)
	Mean (n=23)	30.4±0.2	13.04±0.1	56.5±0.3* ($t_{3.5}$=87)
	High	-	-	-
6 years	Low (n=68)	51.5±0.3* ($t_{3.5}$=26.3)	5.8±0.1	42.7±0.2
	Mean (n=116)	39.7±0.2	12.1±0.1	48.3±0.2* ($t_{3.5}$=28.6)
	High (n=44)	59.1±0.3* ($t_{3.5}$=113.7)	15.9±0.1	25±0.2
7 years	Low (n=2)	50±0.3	0	50±0.3
	Mean (n=187)	55.6±0.3* ($t_{3.5}$=87.3)	14.9±0.1	29.4±0.2
	High (n=64)	56.3±0.3* ($t_{3.5}$=104.3)	18.8±0.2	25±0.2
8 years	Low	-	-	-
	Mean (n=61)	77.1±0.3* ($t_{3.5}$=224.3)	13.1±0.1	9.8±0.1
	High (n=16)	87.5±0.3* ($t_{3.5}$=250)	0	12.5±0.1

M – mediana, SD – standard deviation, * - p<0.001 - the probable difference between the indicators.

Harmonic PD is observed in 6 years old children group of low (51.5±0.3%, p<0.001) and high (59.1±0.3%, p<0.001) levels of GMS. The highest proportion of disharmonic PD with excess body weight was established in children of 6 years old with a mean level of GMS (48.3±0.2%, p<0.001).

Regardless of the level of GMS, the proportion of harmonic PD of 7 and 8 years old schoolchildren is higher than the proportion of children with disharmonious PD. However, among the 7-year-old students with a low level of GMS, there are no differences in PD. It should be noted that the schoolchildren at the age of 8 lack a low level of GMS which is confirmed by the harmony of the child's PD and the favorable influence of the process of adaptation.

According to the results of anthropometric research among the surveyed, the smallest index of growth was observed for children with low level of GMS (115.8±0.6 cm) in comparison to the high and mean levels of GMS (122.7±0.5 cm and 122.7±0.4 cm respectively) (Table 2).

According to the results of mean values of anthropometric indicators, children agedfrom5 to 8 years old have no differences depending on their group of GMS (Table 3).

According to the survey it was found that the highest values of body length (BL) and chest circumference (CC) (120.9 ± 0.7 cm, 60.6 ± 0.6 cm, respectively, p <0.05) were determined for 6-year-old children of high level of GMS.

The dynamometry and comparative characteristic of the indicators of muscle strength of the hand showed that there is a natural increase in the strength of the hand of both girls and boys (p<0.05).Absolute data of the right and left hand strength of children aged from 5 to 8 years old are within 9.1 kg, according to sexual characteristics this index was: boys - 9.85 kg, and girls – 8.30 kg. The increase in the hands strength was slightly more intense among boys of 6 years old compared to girls (9.03 kg and 7.62 kg respectively, p<0.05).In addition, girls of 7 and 8 years old have no significant difference in the strength of hand (p>0.05), and among the pupils of 6 and 7 years old the excess of hand strength reaches 1.48 kg (Figure 3).

Table 2. Characteristics of indicators of physical development of children with different levels of graph-motor skills (M±SD)

Level of GMS	Gender	Physical development indicators		
		BL [cm]	BW [kg]	CC [cm]
high	Ingeneral (n=124)	122.7±0.5*** ($t_{в.н}$=8.9)	23.6±0.4*** ($t_{в.н}$=3.8)	60.3±0.5* ($t_{в.н}$=2.7)
	Girls (n=57)	122.6±0.8*** ($t_{в.н}$=5.8)	23.4±0.6* ($t_{в.н}$=1.9)	60.3±0.6* ($t_{в.н}$=2.3)
	Boys (n=67)	122.8±0.7*** ($t_{в.н}$=6.8)	23.8±0.5*** ($t_{в.н}$=3.4)	60.3±0.7
mean	Ingeneral (n=387)	122.7±0.4** ($t_{с.н}$=9.4)	23.9±0.4** ($t_{с.н}$=5.3)	60.6±0.4** ($t_{с.н}$=4.6)
	Girls (n=181)	121.3±0.5** ($t_{с.н}$=5.4)	23.1±0.3° ($t_{с.н}$=2.3)	59.7±0.3
	Boys (n=206)	123.8±0.5** ($t_{с.н}$=8.1)	24.5±0.3** ($t_{с.н}$=5.1)	61.5±0.3** ($t_{с.н}$=4.8)
low	Ingeneral (n=118)	115.9±0.6	21.6±0.4	58.7±0.3
	Girls (n=58)	115.8±0.9	21.7±0.5	58.6±0.5
	Boys (n=60)	116.03±0.7	21.5±0.5	58.8±0.5

M – mediana, SD – standard deviation, * - p<0.05 - the probable difference between the indicators of low and high levels of GMS; ° - p<0.05 - the probable difference between the indicators of low and average levels of GMS; ** - p<0.001 - the probable difference between the indicators of low and average levels of GMS; *** - p<0.001 is the probable difference between the indicators of low and high levels of GMS.

Table 3. Characteristics of indicators of physical development of children with different levels of graph-motor skills depending on their age (M ± m)

Level of GMS	Age	Physical development indicators		
		BL [cm]	BW [kg]	CC [cm]
high	5 years	–	–	–
	6 years, n=44	120.9±0.7* (t_{в.н}=2.2)	22.5±0.6	60.6±0.6* (t_{в.н}=1.9)
	7 years, n=64	122.7±0.7** (t_{в.с}=1.9)	23.7±0.6	59.6±0.8** (t_{в.с}=2.2)
	8 years, n=16	127.6±1.3	26.1±1.2	62.6±0.5
mean	5 years, n=23	112.8±0.9	20.5±0.5	57.5±0.7
	6 years, n=116	118.8±0.6	22.6±0.4	59.7±0.4
	7 years, n=187	124.2±0.4° (t_{с.н}=2.6)	24.4±0.3	61.1±0.3
	8 years, n=61	128.9±0.7	25.9±0.5	62.3±0.5
low	5 years, n=48	112.2±0.7	20.3±0.4	58.02±0.5
	6 years, n=68	118.5±0.7	22.5±0.5	59.1±0.5
	7 years, n=2	114.5±2.5* (t_{в.н}=1.9)	21±3	59±4
	8 years	–	–	–

* - p<0.05 - the probable difference between the indicators of low and high levels of GMS; ° - p<0.05 - the probable difference between the indicators of low and average levels of GMS; ** - p<0.05 - the probable difference between the indicators of the average and high levels of GMS.
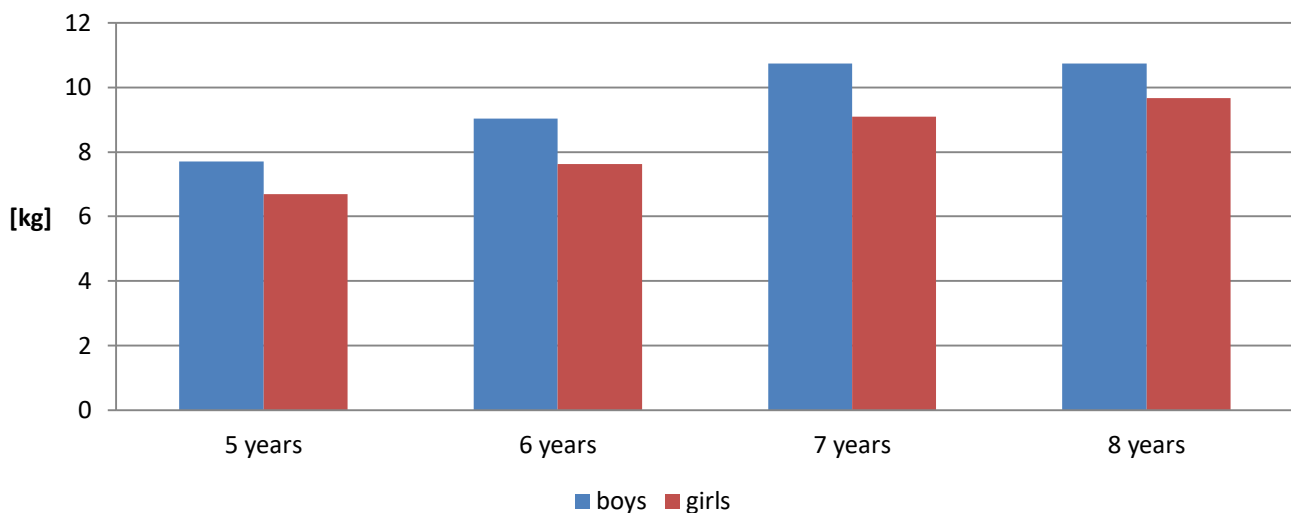
Figure 3. Mean values of the hand strength of children aged from 5 to 8 years [kg].

Table 4. Average indicators of dynamometry of children aged from 5 to 8 years old with different levels of graph-motor writing skills (M ± m)

Level of GMS	Gender	Indicators of dynamometry		
		right hand strength [kg]	left hand strength [kg]	dynamometry index [standardunit]
high	in general, n=94	10.3±0.3*** ($t_{B.H}$=5.2)	9.6±0.3*** ($t_{B.H}$=5.4)	40.8±1.8*** ($t_{B.H}$=3.03)
	girls, n=44	9.7±0.4*** ($t_{B.H}$=3.2)	8.9±0.4*** ($t_{B.H}$=3.6)	38.8±2.7°° ($t_{B.H}$=2)
	boys, n=50	10.8±0.4*** ($t_{B.H}$=4.3)	10.1±0.4*** ($t_{B.H}$=4.2)	42.4±2.5
mean	in general, n=315	9.5±0.2* ($t_{B.C}$=2.2)	9.1±0.2** ($t_{C.H}$=4.8)	36.7±1.02* ($t_{C.H}$=2.1)
	girls, n=145	8.5±0.2	8.2±0.2	34.2±1.5
	boys, n=163	10.4±0.2** ($t_{C.H}$=3.9)	9.9±0.2** ($t_{C.H}$=4.1)	35.8±1.5* ($t_{C.H}$=2.1)
low	in general, n=101	8.1±0.3** ($t_{C.H}$=4.1)	7.5±0.3	32.1±2.2
	girls, n=52	7.5±0.5° ($t_{C.H}$=1.9)	6.9±0.5° ($t_{C.H}$=2.8)	29.8±3.5
	boys, n=51	8.6±0.3	8.1±0.3	39.1±2.2

* - p<0.05 - the probable difference between the indicators of the average and high levels of GMS, ° - p<0.05 - the probable difference between the indicators of low and average levels of GMS, °° - p<0.05 - the probable difference between the indices of low and high levels of GMS, ** - p<0.001 - the probable difference between the indicators of low and average levels of GMS, *** - p<0.001 is the probable difference between the indicators of low and high levels of GMS.

Considering, that students of one age have different GMS, the important significance for detection of parts of GMS physiological component has not just absolute index of dynamometry, but relative – dynamometry index (DI), the specific gravity of hand strength per kg of body weight, which is important for determining the components of the physiological part of graphic readiness. The highest average relative strength values were established among children with high levels of GMS (40.8 s. u.) compared to the mean and low levels of GMS (36.7 s. u. (p<0.05) and 32.1 s. u. (p<0.001), respectively), which testifies to the perfection of the development of muscle strength of the hand among children with the formation of writing skills' automation (Table 4).

This confirms a direct correlation between the DI and the mean values of the GMS (r = 0.24, p <0.05) which may indicate an increase of relative strength during the formation of graph-motor skills.

The dynamometry characteristics, have differences at the age of 6. Thus, 6-years-old children with a high level of GMS have the RHS 1.7 kg and LHS 1.3 kg higher than children with low level of GMS. At the same time, children with a mean level of GMS have RHS 1.1 kg lower than children with high levels of GMS (Table 5).

Table 5. Average indicators of dynamometry of children of different ages with different levels of graph-motor writing skills formation (M ± m)

Level of GMS	Gender	Indicators of dynamometry		
		right hand strength, [kg]	left hand strength [kg]	dynamometry index [standardunit]
high	5 years	-	-	-
	6 years, n=43	9.6±0.4($t_{в.н}$=2.3)	8.9±0.4 ($t_{в.н}$=2.8)	41.9±2.8°° ($t_{в.н}$=3)
	7 years, n=47	10.6±0.4	9.8±0.4	39.2±2.7
	8 years, n=16	10.8±0.9	10.5±0.9	34.6±6.3
mean	5 years, n=23	6.9±0.5	6.6±0.5	24.4±4.2
	6 years, n=93	8.5±0.3 ($t_{в.с}$=2.1)	8.1±0.3	33.3±1.8 ($t_{в.с}$=2.5)
	7 years, n=178	10.1±0.2	9.6±0.2	40.3±1.5
	8 years, n=65	10.5±0.4	9.9±0.4	37.9±2.7
low	5 years, n=48	7.7±0.6	7.5±0.5	29.8±2.7
	6 years, n=60	8.3±0.3	7.6±0.3	30.4±2.4
	7 years, n=2	7±1	7±1	54.2±7.7
	8 years	-	-	-

* - $p < 0.05$ - the probable difference between the indicators of the average and high levels of GMS, ° - $p < 0.05$ - the probable difference between the indicators of low and average levels of GMS, °° - $p < 0.05$ - the probable difference between the indices of low and high levels of GMS, ** - $p < 0.001$ - the probable difference between the indicators of low and average levels of GMS, *** - $p < 0.001$ is the probable difference between the indicators of low and high levels of GMS.

The index of dynamometry reflects the established differences in absolute data of the hand strength of the 6-year-old children, which show the highest values of the DI of children with high levels of GMS (41.9 ± 2.8%) compared to the groups of children with a mean (33.3 ± 1.8%) and low levels of GMS (30.4 ± 2.4%).The difference in DI of children groups is low compared to high-level GMS of children (11.5%).

Age peculiarities of the formation of hand strength of children with different levels of GMS confirm the importance of the level of development of static strength precisely for 6 years old children, this is the age of increased demands for writing skills mastery.

DISCUSSION

The assessment of PD showed that 52.8 ± 1.9% of children have a harmonious development, among them boys are over (58.3 ± 2.7%) the group of girls (46.6 ± 2.8%). The discrepancy between the parameters of length and body weight, which is estimated as disharmonious development, is more often manifested in the excess weight of the body in relation to its length. The number of children with disharmonious development, detected by excess body weight, in these age groups was 34.5 ± 1.9% on average, whereas 12.7 ± 1.3% of the subjects were with insufficient body weight which is characterized as for boys (29.7 ± 2.5% and 12.01 ± 1.8% respectively) and for girls (39.9 ± 2.8% and 13.5 ± 1.9% respectively).

As a result of work it is established that regardless of the children's gender, the majority of individuals with high levels of GMS has a harmonized PD compared to a group of children with low levels of GMS. Children with low levels of GMS have disharmonious physical development which is characterized by excess body weight.

Individual analysis of anthropometric indicators allowed to allocate among the surveyed children's contingent a "risk" group which includes individuals with excess body weight or its deficit.

The age-specific features of PD of children with different levels of GMS are: the harmonization of physical development increases with age which is logical according to biological developmental age; the age of 7 can be a transitional period of the PD harmony's effect on the formation of children's graph-motor skills which is confirmed by the established correlation between the index of GMS and age (r = 0.48, p <0.001); regardless of age, children with a low level of GMS have disharmonious PD

due to excess body weight, whereas harmonic PD is formed in groups of children with high level of GMS, which may be the basis for the formation of graphic readiness of children aged from 5 to 8 years old. So, we can note that the development of strength qualities of children of 5-8 years old for boys occurs with more significant increases than for girls, which indicates a delay in the development of strength qualities of girls.

Analysis of the absolute values of the hand strength of the subjects showed that strengths are the biggest in the groups with high level of GMS. The strength of the right hand and left hand of the children of the group with high level of GMS are for 2.2 and 2.1 kg higher than those of children with low GMS. For girls and boys, the same value of the variation of RHS is determined depending on the level of the GMS – 2.2 kg, as for the values of LHS – 2.0 kg.

The results of the study indicate a negative trend in PD of modern children, which causes high vulnerability of such children to any negative factors of endogenous and exogenous origin. On the one hand, the main efforts should be directed to improving the socio-economic conditions of life and the environment. On the other hand, we need to optimize the educational process in modern educational institutions, as well as timely preventive and recreational measures among the children's population.

CONCLUSIONS

The results of the comparative analysis among the surveyed children with low levels of graph-motor skills, the body mass index and chest circumference were slightly lower than those of children of other levels of graph-motor skills, which both boys and girls are characterized.

Endogenous factors influencing the formation of graph-motor skills are determined: physiological (28.16%) (quality of functional systems and physical parameters of the child); cognitive (19.33%) (level of development of mental processes), personal readiness (14.62%) (contains motivational, emotional, volitional character).

Mechanisms of physiological adaptation play an important role in child'sadaption to the new conditions of the educational process, knowledge of their peculiarities is necessary for the early detection of minimal deviations in their state of health and the timely application of corrective measures.

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