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Analysis of anthropometric indicators of visually impaired children in relation to their healthy peers and according to subgroups of a special medical group

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Abstract

Purpose. The purpose of this study is to conduct a comparative analysis of physical development indicators as one of the criteria for the health status of children with visual deprivation, based on the special medical subgroup, in comparison with their relatively healthy peers.

Material & Methods. Guided by ethical principles and based on informed consent, a study was conducted involving 27 children aged 10. Among them, 13 children had visual deprivation, specifically 8 children were assigned to subgroup A, and 5 to subgroup B. Additionally, 14 relatively healthy children participated in the study. The assessment of physical development was carried out through anthropometric measurements, including body weight, body length, chest circumference, and chest excursion, following standard methodology.

Results. The corresponding statistical analysis revealed that the difference between the groups is statistically significant at the level of $p<0.01$ only for the indicators of chest circumference on inhalation and exhalation in centimeters, as well as for the chest circumference based on the sigma coefficient. For the rest of the indicators, the differences do not reach a sufficient level of statistical significance. These data indicate that 10-year-old children with visual deprivation significantly differed from their peers without visual deprivation in having a significantly larger chest circumference. Children from subgroup B are slightly taller, have a greater body mass, and exceed the chest circumference on inhalation and exhalation of children who, based on medical criteria, fall into subgroup A. However, all these differences, according to statistical criteria, are not pronounced enough to be considered significant for making decisions regarding the specific design of a program for correcting motor disorders during physical education sessions.

Conclusions. The study confirmed data showing that children with visual deprivation exhibit higher body weight indicators compared to their peers without visual deprivation. This is attributed to a sedentary lifestyle resulting from visual analyzer dysfunction. Comparing the anthropometric indices of children with visual deprivation of subgroup A and subgroup B, insignificant differences were found. The only indicator that significantly distinguishes these groups of children is chest excursion, where most children in subgroup A have a difference of 4 cm between the circumference of the chest during inhalation and exhalation, and children in subgroup B have a difference of only 3 cm. The statistical significance of such differences was confirmed by the Mann-Whitney test at the level of $p\leq0.05$.

Keywords: visual deprivation, children, analysis, chest excursion, chest circumference, anthropometric measurements, chest excursion, body weight, body height.

Introduction

It is known that disorders and abnormalities in the functioning of the visual analyzer negatively affect the physical and motor development of children with visual deprivation (Brian et al., 2019; Bakke et al., 2019; Veldhors et al., 2023). Researchers also note a deterioration in the health status of children with visual impairment (Brian et al., 2019; Veldhors et al. 2023). Children with visual impairment have certain specifics of physical development. Anthropometric analysis (based on body length and weight, chest circumference) shows that weight indicators in children with visual impairment are higher compared to their healthy peers (Grygus et al., 2019; Ghasemi et al., 2023; Harlins'ka (Leychenko) et al., 2021). Children with visual deprivation have lower body length than their healthy peers. Analysis of modern scientific research data indicates that there is a certain disproportion in the ratio of body weight and length in children with visual deprivation. Scientists suggest that due to insufficient motor activity caused by difficulties in visual-spatial orientation, children with visual deprivation exceed age norms in body weight (Hatt et al., 2020; Huurneman & Boonstra, 2016; Savliuk et al., 2020; Ghasemi et al., 2023). However, in body length they lag behind the norm (Savluik, 2017). Such changes may be due to difficulties in visual-motor orientation (Harlins'ka (Leychenko) et al., 2021; Kirk et al., 2023), which further lead to hypodynamia, which in general negatively affects the development of motor activity of children with visual deprivation (Harlins'ka (Leychenko) et al., 2021). Scientists note that physical education and sports in a specialized educational institution are necessary to improve the health status, correct the manifestation of motor disorders and improve the physical development of children with visual impairment (Hatt et al., 2020; Radzo, 2023). It is known that the main factors determining participation in physical culture and sports activities of children with visual deprivation are: the nature of the pathology of the visual organ, health status (Savliuk et al., 2020), physical development (Savluik, 2017), functional state of the cardiovascular, respiratory and musculoskeletal systems, level of general physical and psychological fitness (Ortibus et al., 2019).

The main form of physical education classes in a specialized educational institution is a lesson (Hatt et al., 2020). A physical education lesson for children with visual impairment differs from a lesson in a general education institution (Savliuk et al., 2020). The main difference is that it has a corrective focus not only on secondary deviations in physical development and motor fitness of the child, but also on restoration of primary visual impairment (Grygus et al., 2019), improvement of the functional state of cardiovascular, respiratory, musculoskeletal and other systems, level of health in general and development of compensatory functions of the sensory system of children with visual impairment (Grygus et al., 2019; Bakke et al., 2019).

The content of the physical education lesson for children with visual impairment is determined by the tasks of the physical education program material for children with visual impairment (Hatt et al., 2020), which provides for an appropriate level of health, physical development, appropriate functional state of the cardiovascular, respiratory systems, musculoskeletal system, etc (Kirk et al., 2023).

Health criteria are the basis for determining restrictions and contraindications to physical activity. This is due to the relevance of research on physical development indicators, which is one of the main health criteria for children with visual impairment. The process of physical culture for children with visual impairment is implemented in accordance with the established special medical group, which is divided into subgroups: A, B, C (Sheremet et al., 2014).

Subgroup A includes children who do not require restrictions in physical education (they are engaged in physical education programs for visually impaired children), have good health, age-appropriate level of physical development, functional state of the cardiovascular, respiratory and musculoskeletal systems, physical and psychological fitness (Sheremet et al., 2014). Children in this group may have the following visual impairments: hereditary tapetal-retinal dystrophy; hereditary optic atrophy; corneal opacities; atrophy and subatrophy of the eyeball; non-progressive keratoconus; hyperopic type of clinical refraction; consequences of inflammatory retinal diseases (Sheremet et al., 2014).

Subgroup B includes children who need to limit physical activity during physical education classes (engaged in physical education programs for visually impaired children) due to damage to the visual organ, or in case of insufficient health, physical development, functional state of the cardiovascular, respiratory systems and musculoskeletal system, physical or psychological fitness (Sheremet et al., 2014). This subgroup also includes children with the following visual impairments: compensated glaucoma; complicated high myopia; optic nerve atrophy; macular degeneration (without a tendency to hemorrhage and retinal detachments); diabetic, hypertensive angiopathy; congenital complicated cataracts; aphakia (Sheremet et al., 2014). Representatives of group B do not master the process of physical education in the classroom; individual classes are implemented for them. Since representatives of this subgroup have severe congenital or acquired dysfunctions or abnormalities of the visual analyzer (Sheremet et al., 2014).

Material and methods of research

Study Design

The scientific research was carried out in com-

pliance with the main provisions of the "Rules of Ethical Principles of Conducting Scientific Research with the Participation of Humans" approved by the Declaration of Helsinki (1964–2013). Parents gave written consent for their children's participation in the study.

Subjects

Guided by ethical principles and on the basis of informed consent, a study was conducted in which 27 children aged 10 participated. Of these, 13 children with visual deprivation, namely 8 children were assigned to subgroup A and 5 to subgroup B. Also, 14 relatively healthy children took part in the study. The scientific research are took place at the Rehabilitation Center "Zoresvit" (Odesa, Ukraine). Deprivation of vision was presented in the form of dysfunction of the visual analyzer of various degrees of manifestation. According to the data of the medical records, the subjects were diagnosed with: congenital hereditary myopia of medium degree, convergent strabismus, amblyopia and other.

The tasks set in the research were addressed using commonly accepted methods: theoretical analysis of scientific literature on the chosen research topic, standard anthropometry, and mathematical data processing. Physical development was assessed by an anthropometric examination of body weight and length, chest circumference and chest excursion according to the standard method.

Statistical data analysis

As for the methods of statistical data processing, the primary statistical processing of the research materials, analysis of variance (ANOVA) and factor analysis (using the principal component analysis with Varimax rotation), as well as methods of comparing independent samples were used. In the process of mathematical processing, the following statistical characteristics were calculated: to describe the primary statistics, the arithmetic mean (x), standard deviation (S), median (Me) and quartiles of the distribution were calculated; to check the distribution of results for normality, the Kolmogorov-Smirnov (D) and Shapiro-Wilk (W) concordance criteria were used; to compare independent samples depending on the nature of the data distribution, the Mann-Whitney U-test, Student's t-test were used. The statistical processing of the study results was carried out using IBM SPSS Statistics 21 software, and the graphical material was prepared in Microsoft Excel.

Results of the study

According to the results of the study, it was found that the values of the body weight of the subjects ranged from 30.8 kg to 65.2 kg with a mean value of 46 kg and a standard deviation of 9.79 kg (46±9.79). The body length of the subjects ranged from 144.5 cm to 162.5 cm and averaged (154.88±6.04) cm. The index of chest circumference during inspiration ranged from 66 cm to 94 cm with an average value of (80±7.34) cm, during expiration – from 62 cm to 91 cm with an average value of (76.23±8.53) cm, and accordingly the lowest values of chest excursion were 3 cm, the maximum – 6 cm, and the average score was (3.77±1.01) cm.

The data presented in Figure 1 showed that the majority of children with visual impairment had

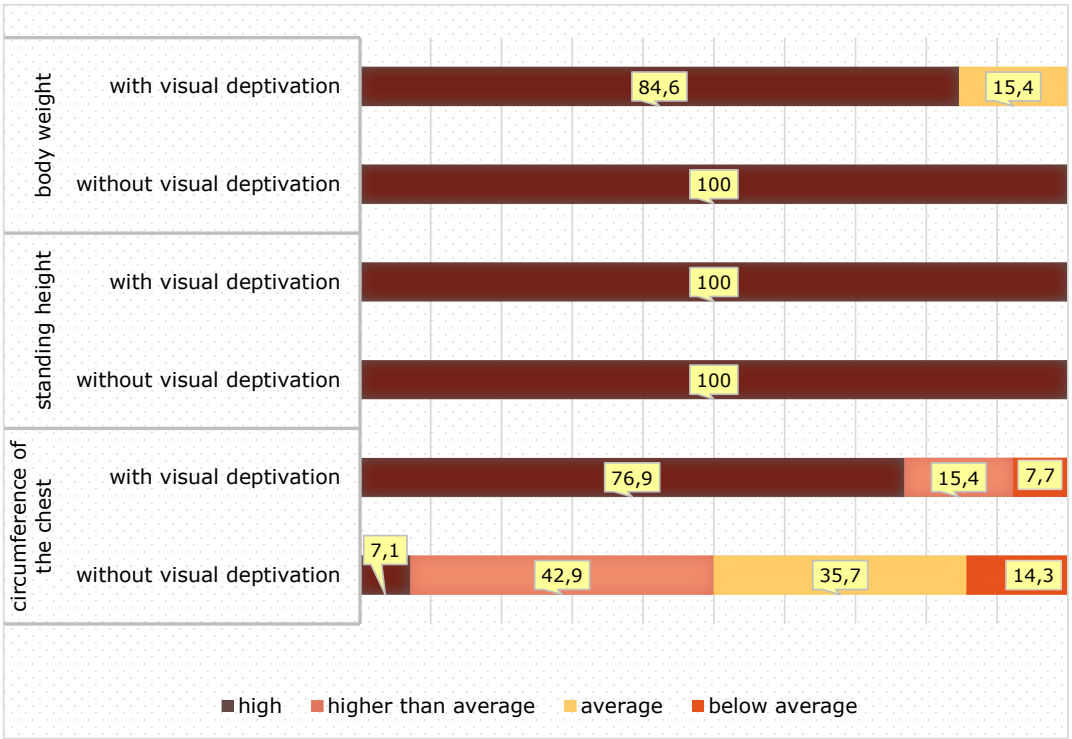

Figure 1. Distribution of children with visual deprivation and without visual deprivation based on the severity of anthropometric indicators in percentages, illustrating developmental levels.

body weight that exceeded the norm for their age, as this indicator in 84.6% of the study population corresponded to a high level, and only 15.4% to an average level. The distribution of body length indicates that children with visual impairment are tall (100%). In terms of chest circumference, 76.9% of children's individual data corresponded to the high level, 15.4% to the above average level, and 7.7% to the below average level. At the same time, according to the chest examination, the majority of children (92.3%) demonstrated average development, and the rest (7.7%) – good development. That is, the majority of 10-year-old children with visual deprivation were characterized by higher than normal weight, body length and chest circumference, and average excursion between inspiration and expiration.

If we turn to the data on the physical development of the 10-year-olds without visual deprivation, the latter have the same range of individual values in terms of body weight and length as the previous group, namely, all the children examined are overweight and overweight. In terms of chest circumference, where the vast majority of children in the visually impaired group had high values, only 7.1% of their peers had high values. The higher than normal level was observed in 42.9% of them, and the average level – in 35.7%. That is, chest circumference that exceeds the norm is more common among children with visual deprivation. In terms of chest excursion, children with moderate values prevailed in the group of 10-year-olds without visual deprivation (85.7%), and only a few had good excursion (14.3%). Consequently, 10-year-old children without visual deprivation have a uniform physical development characterized by overweight and body length. However, their chest circumference is more variable and less pronounced than in children of this age with visual deprivation, with a small difference in chest excursion between these groups of children. Further analysis of the physical development indicators of the subjects, which, in particular, included a comparison with similar data obtained in the study of their peers without visual deprivation, involved checking the results for normality of distribution (Table 1).

The data presented in the table indicate that in both groups of 10-year-old children the nature of the distribution of estimates is close to normal in terms of body weight and inspiratory chest circumference. At the same time, body length, expiratory chest circumference, and chest excursion demonstrate a variation of data that differs significantly from normal. Therefore, for the statistical analysis of data comparing the study group of 10-year-old children with their peers without visual deprivation, data distributed according to the normal law will be presented as the arithmetic mean ± standard deviation, and for data whose distribution differed from the normal, we will focus on the median and interquartile range. Accordingly, student's was used to determine the statistical significance of differences between groups for body weight and inspiratory chest circumference, and the nonparametric Mann-Whitney U test was chosen for the other indicators. If we turn to the data obtained on anthropometric indicators in groups of 10-year-old children with visual deprivation and their peers without visual deprivation, the direction of differences between them becomes noticeable (Table 2).

The relevant statistical analysis showed that the difference between the groups was statistically significant at the level of $p<0.01$ only in terms of chest circumference on inspiration, exhalation

Table 1. The results of checking the distribution of physical development indicators in 10-years-old children with and without visual deprivation for normality

Indicators	10 years with visual deprivation (n=13)				10 years without visual deprivation (n=14)			
	Kolmogorov-Smirnov with Liliefors correction		Shapiro-Wilk		Kolmogorov-Smirnov with Liliefors correction		Shapiro-Wilk	
	D	p	W	p	D	p	W	p
Body weight, kg	0,106	p>0,20	0,978	p>0,20	0,177	p>0,20	0,955	p>0,20
Height, standing, cm	0,235	p<0,05	0,871	p<0,10	0,237	p<0,05	0,756	p<0,05
Chest circumference, inhale, cm	0,146	p>0,20	0,985	p>0,20	0,110	p>0,20	0,972	p>0,20
Chest circumference, exhale, cm	0,180	p>0,20	0,967	p>0,20	0,237	p<0,05	0,750	p<0,05
Chest excursion	0,315	p<0,05	0,776	p<0,05	0,260	p<0,05	0,841	p<0,05
Body weight (σ)	0,145	p>0,20	0,966	p>0,20	0,137	p>0,20	0,954	p>0,20
Height, standing (σ)	0,273	p<0,05	0,880	p<0,05	0,216	p<0,05	0,878	p<0,05
Chest circumference (σ)	0,170	p>0,20	0,948	p>0,20	0,226	p<0,05	0,815	p<0,05

Notes. σ – value according to the sigmoidal criterion; n – number of subjects; D – value of the Kolmogorov-Smirnov criterion; p – level of reliability; W – value of the Shapiro-Wilk consistency criterion.

Table 2. Differences in the severity of physical development indicators between 10-years-old children with visual impairment and their peers without visual impairment

Comparable groups	Statistical indicators	Indicators of physical development							
		Body weight, kg	Body length, cm	Chest circumference, inhalation, cm	Chest circumference, exhale, cm	Excursion	Body weight (σ)	Body lenght (σ)	Chest circumference (σ)
With visual deprivation (n=13)	$\bar{X}$	46,01	154,9	80	76,23	3,77	3,66	3,75	2,94
	s	9,79	6,04	7,34	7,53	1,01	2,44	1,39	2,28
	Me	46,8	158	78	75	3	4	4,6	2,2
	25%	40,8	151,5	76	73	3	2,15	2,57	1,69
	75%	51,5	159	85	81	4	4,43	4,83	4,65
With visual deprivation (n=14)	$\bar{X}$	44,71	156	71,79	69	4,14	3,32	3,84	0,7
	s	3,02	2	2,58	6,53	1,23	0,9	0,72	1,59
	Me	44,5	156,5	72	69	4	3,21	4,1	0,69
	25%	43	155	70	65	3	2,84	3,3	–0,35
	75%	47	157	73	70	5	4,09	4,41	1,23
Reliability of differences	t	0,45	-	3,51	-	-	0,47	-	-
	U	-	78	-	30	74,5	-	80	29
	p	p>0,05	p>0,05	p<0,01	p<0,01	p>0,05	p>0,05	p>0,05	p<0,01

Notes: 1. Here and further: – mean arithmetic value; Me, 25%, 75% – median and quartiles of the distribution; s – standard deviation; t – Student's t-test value; U – Mann-Whitney U test value; p – level of significance of differences.

2. The level of significance of differences was determined using the following critical values: U_critical(13; 14; 0.01) = 38; t_critical(25; 0.01) = 2.79.

Table 3. Results of checking the normality distribution of physical development indicators in 10-year-old children assigned to subgroups A and B

Indicators	Children of the subgroup A (n=8)				Children of the subgroup B (n=5)			
	Kolmogorov-Smirnov with Liliefors correction		Shapiro-Wilk		Kolmogorov-Smirnov with Liliefors correction		Shapiro-Wilk	
	D	p	W	p	D	p	W	p
Body weight, kg	0,203	p>0,20	0,876	p>0,10	0,194	-	0,967	p>0,20
Height, standing, cm	0,193	p>0,20	0,947	p>0,20	0,367	-	0,729	p<0,05
Chest circumference, inhalation, cm	0,132	p>0,20	0,982	p>0,20	0,235	-	0,952	p>0,20
Chest circumference, exhale, cm	0,188	p>0,20	0,959	p>0,20	0,235	-	0,952	p>0,20
Chest excursion	0,220	p>0,20	0,917	p>0,20	-	-	-	-
Body weight (σ)	0,205	p>0,20	0,904	p>0,20	0,192	-	0,973	p>0,20
Height, standing (σ)	0,239	p>0,20	0,927	p>0,20	0,377	-	0,717	p<0,05
Chest circumference (σ)	0,214	p>0,20	0,910	p>0,20	0,209	-	0,982	p>0,20

in centimeters, and chest circumference by sigmoidal coefficient. For the remaining indicators, the differences do not reach a sufficient level of statistical significance. These data indicate that 10-year-old children with visual deprivation significantly differed from their peers without visual deprivation in having a significantly larger chest circumference. Before moving on to consider the indicators of physical development of children in these groups, let us define the nature of their distribution (Table 3) in accordance with the special methodological subgroups A and B.

The data presented in the table show that all physical development indicators in 10-year-old children from subgroup A are normally distributed. However, only four 10-year-old children from subgroup B were found among the subjects, so it is impossible

to check the distribution of their measurements for normality according to the Kolmogorov-Smirnov criterion. Based on the results of the Shapiro-Wilk test, a similar normal distribution was recorded for body weight, chest circumference at inhalation and exhalation. Therefore, the right decision is to characterize children from these groups by body weight and chest circumference, taking into account the average values, and the rest of the indicators - focusing on the medians and quartiles of the distributions. Similarly, the t-test was used to compare groups by weight and chest circumference, and the U-test by body length and excursion (Table 4).

As shown in Table 4, children from subgroup B are slightly taller, have a higher body weight, and exceed children who were included in subgroup A by medical indicators in terms of chest circumference at inhalation and exhalation. However, all these differences are not sufficiently pronounced according to statistical criteria, and therefore cannot be considered significant for making a decision on the specific design of a program for the correction of motor disorders in the process of physical education.

Discussion

The results of the study are consistent with the existing data of modern scientific research and are supported by new data. Based on the data obtained on the physical development of children aged 10 years with visual impairment, certain assumptions can be made (Grygus et al., 2019; Bakke et al., 2019; Huurneman & Boonstra, 2016). The majority of children with visual impairment are characterized by higher than normal body weight, body length and chest circumference. There are additional data confirming the fact that children with visual deprivation have a significantly larger chest circumference compared to children without visual deprivation (Brian et al. 2019; Savliuk et al., 2020; Carlijn Veldhors et al., 2023; Ghasemi et al., 2023). The study of differences in the severity of anthropometric indicators in groups of 10-year-old children with visual deprivation, which are assigned to subgroup A and subgroup B of the group, is relevant from a psychophysiological and medical point of view (Sheremet et al., 2014). Such an analysis can help to identify possible physical features of these two groups and be of practical importance for the correction of motor disorders in these children. Children aged 10 years with visual deprivation from subgroup A have a greater chest excursion compared to children from subgroup B, which indicates their better physical condition.

Analyzing the data obtained in the presented research study in comparison with the indicators of previous years' studies, it can be assumed that 10-year-old children with visual deprivation were inferior in anthropometric indicators: height and body weight, as well as excursion, compared to their relatively healthy peers (Savliuk, 2017). In terms of body weight, children aged 10 years with visual impairment lag behind their practically healthy peers from comprehensive schools ($p<0.05$). The data obtained allow us to state that

Table 4. Differences in the expression of physical development indicators among 10-years-old children from subgroup A and subgroup B

Comparable groups	Statistical indicators	Indicators of physical development							
		Body weight, kg	Body length, cm	Chest circumference, inhalation, cm	Chest circumference, exhale, cm	Excursion	Body weight (σ)	Body length (σ)	Chest circumference (σ)
Children of subgroup A (n=8)	$\bar{X}$	43,58	155,6	78,13	73,88	4,25	2,99	3,83	2,12
	s	8,34	5,14	7,3	7,22	1,04	1,94	1,25	1,95
	Me	45	157,3	77,5	73	4	3,57	4	1,69
	25%	37,3	152,5	74	71	4	1,42	2,73	1,38
	75%	50,6	158,5	84	78	5	4,24	4,73	3,72
Children of subgroup B (n=5)	$\bar{X}$	52,93	156	84,75	81,75	3	5,48	4,1	4,76
	s	10,91	6,73	6,8	6,8	0	2,88	1,63	2,37
	Me	52,9	159	83,5	80,5	3	5,55	5	4,53
	25%	44,1	152	80	77	3	3,17	3,15	3,1
	75%	61,8	160	90	87	3	7,78	5,04	6,42
Reliability of differences	t	1,39	-	1,49	1,75	-	1,42	-	1,75
	U	-	12,5	-	-	4	-	13	-
	p	p>0,05	p>0,05	p>0,05	p>0,05	p≤0,05	p>0,05	p>0,05	p>0,05

Notes. The level of significance of differences was determined by the following critical values: $U_{cr}(4; 8; 0,05) = 4$; $t_{cr}(10; 0,05) = 2,23$.

children with visual impairment have statistically significantly lower chest circumference than their healthy peers ($p<0.05$).

Comparing the data of the presented research with the data of physical development indicators of children with visual impairment of previous years (Demchuk, 2015), it is possible to assume that modern approaches to correcting the manifestation of motor disorders in children with visual impairment are more effective, but require further improvements and implementation of new approaches.

Conclusion

The study confirmed that children with visual deprivation exhibit higher body weight indicators compared to their peers without visual deprivation (Dychko, 2018). This is attributed to a sedentary lifestyle, a consequence of visual analyzer dysfunction. The results of the study showed that in terms of body weight and chest circumference (in absolute and sigmoidal values), the values in the group of children with visual impairment are higher than those of their peers without visual impairment. For the remaining indicators, i.e., body length (in absolute and sigmal values) and the absolute difference between the chest circumferences during inspiration and expiration in centimeters, the centers of distribution in the group of children without visual deprivation were higher. The obtained data of the scientific research confirm the scientific research devoted to the peculiarities of the physical development of children with visual impairment (Ayvazoglu, 2006).

Comparing the anthropometric indices of children with visual deprivation of subgroup A and subgroup B, insignificant differences were found. The only indicator that significantly distinguishes these groups of children is chest excursion, where most children in subgroup A have a difference of 4 cm between the circumference of the chest during inhalation and exhalation, and children in subgroup B have a difference of only 3 cm. The statistical significance of such differences was confirmed by the Mann-Whitney test at the level of $p\leq0.05$. Greater chest excursion in children from subgroup A compared to children from subgroup B may indicate a difference in physical condition and respiratory system function. If this is the case, they are able to perform breathing exercises more effectively, which is important when prescribing physical exercises to this category of children. In addition, such knowledge will further help to refine individually oriented programs for the implementation of physical education for 10-year-old children with visual impairment, depending on their capabilities and compliance with the subgroup.

Author's contribution

Conceptualization, B.B.; methodology, B.B.; software, V.K.; check, B.D.; formal analysis, S.R.; investigation, L.P.; re-sources, B.B.; data curation, B.B.; writing – rough preparation, V.K.; writing – review and editing, B.B.; visualization, B.D.; supervision, S.R.; project administration, L.P. All authors have read and agreed with the published version of the manuscript.

Conflict of interest

Author declares that there is no conflict of interests.

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