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Indicators of body asymmetry in relation to the prevention of scoliosis in first graders

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Abstract

Purpose: the purpose of the study was to increase the validity of the indicator of asymmetry in the frontal plane of the body in relation to the prevention of scoliosis in first graders.

Material & Methods: thirty-four students aged six to seven years – 18 boys (with body length and weight M±SD=118,9±2.1 cm; 21,6±1,1 kg) and 16 girls (118,2±1,8 cm, 21,2±0,9 kg) were randomly divided into the main group and the comparison group. In addition to standard physical education lessons, students of the main group completed a program of physical rehabilitation in order to prevent the development of posture asymmetry. At the beginning (September) and the end of the academic year (May), the students were measuring the curvature of the spine in the frontal plane according to the Moshkov test and bending to the sides.

Results: in addition to the well-known model of the Moshkov rhombus, the asymmetry of the students' bodies was determined using an improved indicator equal to half the sum of the absolute values of the differences in the lengths of the upper and lower sides of the Moshkov rhombus. There was no statistically significant difference between the boys, both according to the results of the Moshkov test (δ=0,3%; p=0,512), and according to the results of bending to the sides (δ=1,4%; p=0,379). At the beginning of the academic year, the value of the asymmetry indicator in the main group was practically equal to the corresponding value in the comparison group (*δ*=2,2%; p=0,815). At the end of the academic year, the value of the indicator in the main group was significantly less than its value in the comparison group. (*δ*=32,8%; p=0,031).

Conclusions: the indicator of asymmetry in the frontal plane of the body proposed in this work, due to taking into account the magnitude of the curvature of both the upper and lower parts of the spine, made it possible to obtain a significantly higher validity (p=0,02) compared to the well-known indicator of the Moshkov rhombus, which in one parts of the spine – upper or lower (p=0,05).

Key words: orthopedics, posture, scoliosis, rehabilitation, Moshkov rhombus, modeling.

Анотація

Ігор Заневський, Олена Боднарчук, Людмила Заневська. Індикатори асиметрії тіла стосовно попередження сколіозу у першокласників. Мета: метою дослідження було підвищення валідності індикатора асиметрії у фронтальній площині тіла стосовно попередження сколіозу у першокласників. **Матеріал і методи:** тридцять чотири учні віком шести-семи років – 18 хлопчиків (із довжиною і масою тіла *M*±*SD*=118,9±2,1 см; 21,6±1,1 кг) і 16 дівчат (118,2±1,8 см; 21,2±0,9 кг) були випадковим чином розподілені на основну групу й групу порівняння. Окрім стандартних уроків фізичної культури, учні основної групи виконували програму фізичної реабілітації з метою попередження розвитку асиметрії постави.

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На початку (вересень) й наприкінці навчального року (травень) учні відбували вимірювання викривлення хребта у фронтальній площині за тестом Мошкова й нахилами в боки. **Результати:** на додаток до загально відомої моделі ромба Мошкова асиметрію тіла учнів було визначено з використанням вдосконаленого індикатора, який дорівнює половині суми абсолютних величин різниць довжин верхніх та нижніх сторін ромба Мошкова. Не виявлено статистично істотної різниці між хлопцями й дівчатами як за результатами тесту Мошкова (δ=0,3%; p=0,512), так і за результатами нахилів у боки (δ=1,4%; p=0,379). На початку навчального року величина індикатору асиметричності в основній групі практично дорівнювала відповідній величині у групі порівняння (δ=2,2%; p=0,815). Наприкінці навчального року величина індикатору в основній групі виявилася істотно меншою від його величини у групі порівняння (δ=32,8%; p=0,031). **Висновки:** запропонований у цій роботі індикатор асиметрії у фронтальній площині тіла, завдяки урахуванню величини викривлення як верхньої, так і нижньої частини хребта, дозволив отримати істотно вищу валідність (p=0,02) порівняно із загально відомим індикатором ромба Мошкова, яким враховують викривлення тільки однієї частини хребта – верхньої або нижньої (p=0,05).

Ключові слова: ортопедія, постава, сколіоз, реабілітація, ромб Мошкова, моделювання.

Introduction

Childhood posture disorder is a massive phenomenon in modern primary school, threatening the health of students (Konieczny et al., 2013; Negrini et al., 2018; Bettany-Saltikov, 2017). According to statistics from the Ministry of Health of Ukraine, on the threshold of school, 67% of children have health-threatening posture defects, and 8.4% have scoliosis (Polka et al., 2013).

To diagnose scoliosis, pediatricians use x-rays, magnetic resonance, ultrasound, etc., and changes in posture, for example, asymmetry in the frontal plane of the body, can be detected as an early sign of scoliosis (Singhal et al., 2013; Zezhang et al., 2016; Tan et al., 2018). The appearance of morphological and functional asymmetry of the body is a sign of the threat of the formation of an incorrect posture of elementary school students. To create individual and group profiles of posture asymmetry, batteries of tests of morphological characteristics, assessments of the leading limb, etc. are used (Kudryashova et al., 2020).

On the one hand, a large number of indicators allows you to deeply and comprehensively study the state of body asymmetry, and on the other hand, the practice of school physical education shows that Moshkov morphological indicator and torso tilts to the left and right as a functional indicator are quite informative in predicting scoliosis changes in posture (Prokopiev et al., 2021).

Hypothesis

The generally accepted indicators of the curvature of the spine in the frontal plane of the body are determined taking into account the lengths of the upper and lower half of the Moshkov rhombus, that is, based on the parameters of the cervical and lumbar spine separately (Ali et al., 2021; Watanabe et al., 2017). The idea of our work is to take into account both the upper and lower indicators together by improving the Moshkov rhombus model and thus increase the validity of the asymmetry indicator in the frontal plane of the body relative to the scoliosis predictor indicator in first graders. It is clear that ensuring a sufficient level of validity of health tests is a serious problem in the theory and practice of physical activity of primary school students (Zanevskyy, & Zanevska, 2019; Zanevskyy et al., 2019; Zanevskyy et al., 2017).

Purpose of the study was to increase the validity of the indicator of body asymmetry in the frontal plane in relation to the prevention of scoliosis in first-graders.

Material and methods of research

Participants

Thirty-four students aged six to seven years: eighteen boys (with length and body weight M±SD=118,9±2,1 cm; 21,6±1,1 kg) and sixteen girls (118,2±1,8 cm; 21,2±0,9 kg) were randomly divided into two groups of the same size, the main group and the comparison group, that is, seventeen people in each. All schoolchildren met the health criteria defined by the Ministry of Education and Science and the Ministry of Health of Ukraine, as a result of which they could participate in physical education in accordance with the general curriculum for physical culture (Physical culture, 2016).

The parents of the students gave their written consent to the participation of the students in the study, the program of which was preliminarily approved by the Commission on Scientific Ethics of Lviv State University of Physical Education.

Procedure

The study was conducted in one stage during the 2018-2019 academic year. The students of the main group and the comparison group attended physical education lessons in accordance with the general curriculum. In addition to standard physical education lessons, students of the main group completed a physical rehabilitation program specifically designed to prevent the development of postural asymmetry, the effectiveness of which was previously proven by a separate study (Bodnarchuk, & Bas, 2014). The difference between the

main group and the comparison group was only that the students of the main group, in addition to general physical education, fulfilled the requirements of this rehabilitation program.

At the beginning of the study (September) and before its completion (May), the students were examined and performed tests to determine the asymmetry of the spine in the frontal plane of the body using the Moshkov rhombus (morphological asymmetry), as well as torso tilts to the left and right (functional asymmetry).

Moshkov rhombus

Four vertices of the Moshkov rhombus were marked with a dermographic pencil, namely: the acromial process of the seventh cervical vertebra (A), the angles of the right and left shoulder blades (B and D), respectively, and the acromial process of the fifth lumbar vertebra (C). The length of the sides of the rhombus was measured with a millimeter ruler (Figure 1).

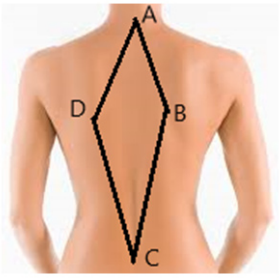

Fig. 1. Scheme of Moshkov rhombus: *A – acromial process of the seventh cervical vertebra, B and D – angles of the right and left shoulder blades, respectively, C – acromial process of the fifth lumbar vertebra.*

In another test (for functional asymmetry), the torso was tilted to the left and right, and the minimum distance of the distal point and the middle finger to the floor was measured with a millimeter ruler. The indicator of functional body asymmetry was defined as the ratio of the right distance to the left floor increased by two orders of magnitude (Figure 2).

Fig. 2. Scheme of the test for functional asymmetry: *h – the minimum distance of the distal point of the middle finger to the floor when the torso is tilted left-right.*

Asymmetry indicators

Two patterns of body asymmetry were investigated (see Figure 1). According to the well-known model of morphological asymmetry, the indicator was defined as the absolute value of the difference in the lengths of the left and right sides of the Moshkov rhombus for the upper part (I_U) and, similarly, for the lower part of the spine (I_L):

$$I_U = |AB - AD|, \quad I_L = |CB - CD| \qquad (1)$$

According to the second model of morphological asymmetry, one indicator was determined as the floor of the sum of a pair of indicators of the upper and lower parts of the spine:

$$I = \frac{I_U + I_L}{2}. \qquad (2)$$

The relative value of the indicator was determined by the ratio of the length of the left side of the rhombus increased by two orders of magnitude to the length of its right side:

$$I = \frac{AD}{AB}100 \qquad (3)$$

Statistical analysis

The normality of the distribution of the value of body asymmetry indicators was checked by two methods, since the volume of the population (n=34) turned out to be on the verge of suitability of the Shapiro-Wilk and Kolmogorov-Smirnov models.

Taking into account the significant difference between the law of distribution of the indicator values from the normal one, the Spearman rank correlation model was applied. Since the dependent statistical samples did not show a normal distribution, the Wilcoxon model was used to compare them. Due to such circumstances, the Mann-Whitney model was applied for independent samples.

The relative difference between the indicators of morphological and functional asymmetry of the body, as well as to assess the corresponding gender differences, the following formula was used (Zanevskyy, & Bodnarchuk, 2020):

$$\delta = \frac{X_2 - X_1}{X_1 + X_2}200\%, \qquad (4)$$

where X_1 is the Moshkov test indicator (see Figure 1), X_2 is the left-right tilt test indicator (see Figure 2).

The relative change in the indicator value during the academic year was determined by the formula:

$$\delta = \frac{X_T - X_B}{X_B}100\%, \qquad (5)$$

where X_B is the test indicator (2) at the beginning of the school year (in September), X_T is the test indicator at the end of the school year (in May).

The significance of Spearman's rank correlation was determined by the t-student parameter (Zatsiorsky, 1982, p. 53):

$$t = |r|\sqrt{\frac{n-2}{1-r^2}}, \quad (6)$$

where r is the correlation coefficient, n is the sample size.

The calculation was made using MS Excel spreadsheets (Data Analysis), as well as the computer package StatSoft Statistica.

Results of the study

Approbation of the model of the proposed posture asymmetry index was carried out using the results of the prevention of spinal curvature in the framework of a well-known rehabilitation program (Bodnarchuk, & Bas, 2014). The level of information content of the indicator was assessed by the similarity of its value when comparing the main group, to which the rehabilitation program was applied, with the comparison group, to which only the standard program of physical culture was applied.

Comparison of the results of boys and girls

Since the hypothesis about the normality of the distribution of the Moshkov test results and left-to-right slopes for both boys (n_m=18) and girls (n_w=16) was rejected (p=0,005÷0,052), the analysis of gender differences was carried out using nonparametric statistics methods (Table 1). According to the Mann-Whitney test, there was no statistically significant difference between boys and girls both in the Moshkov rhombus (δ=0,3%, p=0,512) and in the test of body tilts to the sides (δ=1,4%, p=0,379). Thus, it was shown that the studied students belong to the general general population.

Morphological and functional asymmetry

Statistically significant differences (p<0,001), as well as a close correlation (r=0,697; Table 2), were revealed between the relative values of the indicators of spinal curvature, determined by the Moshkov rhombus and right-left tilts. The corresponding correlation analysis was performed by the Spearman rank correlation method, since the distribution of the results, carried out by the Shapiro-Wilk method, differs significantly from the normal one (p<0,005). Similar conclusions were made using the Kolmogorov-Smirnov method (p<0,05).

On average, the value of functional asymmetry in terms of the relative value of the indicator is 2,3 points (δ=2,2%) more than the corresponding value of morphological asymmetry (see Table 2), but this difference is not statistically significant (p=0,203). In addition, the significance of the studies of children in the combined group is confirmed by the magnitude of the variation (2,9 and 7,6%), which indicates a high homogeneity of these groups.

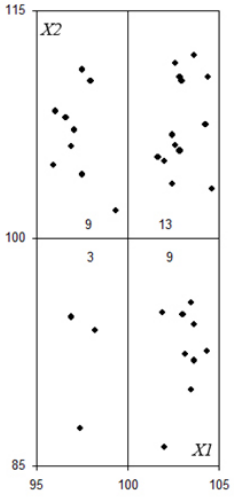

Fig. 3. Correlation field of relative values of the indicators of curvature of the spine (X_1) and tilts left-right (X_2).

Table 1. Results of boys (n_m=18) and girls (n_w=16)

Statistics*	Along the Moshkov rhombus (X_1)		Along left and right tilt (X_2)	
	Boys	***Girls***	***Boys***	***Girls***
Me	102,2	102,5	94,7	96,0
SD	2,9	3,1	9,1	6,5
Max	104,6	104,4	116,0	111,1
Min	95,9	96,0	89,2	90,6
SW-W	0,859	0,824	0,833	0,888
p(W)	0,012	0,006	0,005	0,052
Δ, δ%	0,3; 0,3%		1,3; 1,4%	
U	125,0		118,5	
p(U)	0,512		0,379	

**Notes: Me is the median, SD is the standard deviation, SW-W is the Shapiro-Wilk parameter, p(W) is the significance of the Shapiro-Wilk test, Δ is the absolute value of the difference between the medians of the X_1 and X_2 parameters, δ% is the relative value of the difference of the medians, U is the Mann-Whitney statistic, p(U) is the significance of the Mann-Whitney test.*

Table 2. Indicators of asymmetric posture in the frontal plane (n=34)

Statistics*	Asymmetry parameters	
	Along the Moshkov rhombus (X_1)	Along left and right tilt (X_2)
Me	102,2	104,5
Max	104,6	112,1
Min	95,9	86,2
V%	2,9	7,6
SW-W	0,842	0,901
p(W)	<0,001	<0,005
D	0,172	0,901
p(D)	<0,05	<0,01
Δ, δ %	2,3; 2,2%	
Z	1,27	
p(Z)	0,203	
r	0,697	
p(r)	<0,001	

*__Notes:__ *Me is the median, V% is the coefficient of variation, SW-W is the Shapiro-Wilk parameter, p(W) is the significance of the Shapiro-Wilk test, D is the Kolmogorov–Smirnov parameter, p(D) significance of the Kolmogorov–Smirnov test, Δ is the absolute value of the difference between the medians of the X_1 and X_2 parameters, δ% is the relative value of the difference of the medians, Z is the Wilcoxon statistic, p(Z) is the significance of the Wilcoxon test, r is the Spearman rank correlation coefficient, p(r) is the significance of the correlation.*

Table 3. Results of the experiment on the validity of indicators (n_{mg}=n_{cg}=17)

Parameters *	September				May			
	MG		*CG*		*MG*		*CG*	
	I_U	I_L	I_U	I_L	I_U	I_L	I_U	I_L
M (cm)	0,47	0,46	0,46	0,45	0,25	0,26	0,35	0,36
SD (cm)	0,12	0,15	0,17	0,14	0,12	0,09	0,19	0,13
SW-W	0,920	0,928	0,935	0,947	0,911	0,927	0,932	0,941
p(W)	0,147	0,201	0,272	0,415	0,102	0,192	0,259	0,328
δ%, *p(t)*	2,2%; 0,815		32,8%; 0,031		58,3%; **0,020**		24,7%; **0,050**	

*__Notes:__ MG is main group, CG- comparison group, I_U, I_L is indicators of asymmetry of the upper and lower parts of the spine, respectively (1), *M is the arithmetic mean, SD is the standard deviation, SW-W is the Shapiro-Wilk parameter, p(W) is the significance of the Shapiro-Wilk test, δ % is the relative value of the difference of the medians, p(t) is significance of the T-test for connected populations.*

Regarding the neutral value of the indicator of spine asymmetry according to the Moshkov rhombus and side bends (X1=X2=100, Figure 3), the main group and the comparison group (n=34) were divided into four clusters: 3 students (X1<100, X2<100), 9 students (X1>100, X2<100), 9 students (X1<100, X2>100) and 13 students (X1>100, X2>100).

Rehabilitation program

Since the hypothesis of a normal distribution of the values of the asymmetry indicator was accepted at a satisfactory level of significance, the processing of the measurement results was carried out using the methods of parametric statistics: *p(W)*=0,192–0,415. The parameters of the dynamics of the state of the curvature of the spine of the students of the main group and the comparison group in terms of the value of indicators of asymmetry from September (beginning of the experiment) to May (end of the experiment) are shown in Table 3.

At the beginning of the academic year, the value of the asymmetry indicator in the main group was practically equal to the corresponding value in the comparison group (δ=2,2%; p=0,815). At the end of the academic year, the value of the indicator in the main group was significantly less than its value in the comparison group. (δ=32,8%; p=0,031).

Discussion

The aim of the study was to increase the validity of indicators of spinal asymmetry in the frontal plane of the body. This goal was achieved by improving the model of the asymmetry indicator, which was represented by the sum of the absolute values of the differences in the lengths of the pair of upper and pair of lower sides of the Moshkov rhombus (see Table 3).

Comparison of indicator values

The well-known indicator of the morphological asymmetry of the spine in the frontal plane is equal to the larger of the two absolute values of the dif-

ference between the upper and lower pairs of sides of the Moshkov rhombus. The value of the indicator is determined only by one of the two parts of the spine – upper or lower, while the parameters of the other part are not taken into account (Konieczny et al., 2013; Prokopiev et al., 2021). Such a model assumes the elimination of the parameters of the curvature of one half of the spine and the orientation only to the other half, which obviously reduces the information content of the indicator. For example, the measurement results of one of the students (a girl) in May: –0.5 cm (in the cervical region) and 0.6 cm (in the lumbar region). It seems obvious that the first result is better than the second, however, according to the Moshkov model (Ali et al., 2021), the results of both measurements are 0.6 cm. According to our model, the indicator value is (0,5+0,6)/2=0,55, i. e., less than the second measurement result equal to 0,6 cm.

The correctness of using half the sum of the absolute values of the differences in the lengths of a pair of upper and a pair of lower sides of the Moshkov rhombus as an indicator of asymmetry is confirmed by almost the same differences in the values of indicators in the main and comparative groups both at the beginning (p=0,740; p=0,422) and at the end of the study (p=0,431; p=0,707). Consequently, the "contribution" of the cervical and lumbar regions to the overall asymmetry of the spine is almost the same. Therefore, it is quite correct to add the values of asymmetry corresponding to the upper and lower sections (3).

Gender differences

There were no statistically significant differences between the results of boys and girls (p>0,3) in relation to the asymmetry of the spine in the frontal plane of the body (see Table 1). So, the expediency of studying the asymmetry of the body of first-graders within the framework of a joint group of children without attention to gender differences is substantiated. This approach coincides with the guidance of the Ministry of Education and Science of Ukraine, the National Academy of Medical Sciences of Ukraine and the Ukrainian Center for Scientific and Medical Information and Patent and Licensing Work regarding integral indicators for morphological and functional assessments of the state of posture in children of senior preschool age, which is recommended to be carried out according to the general assessment methodology boys and girls together.

According to this, it is believed that the tendency to scoliosis occurs when the value of the vertical curvature of the spine is more than 110% or less than 90%; in the range of 90-100%, it is considered that it is not physiologically normal (Polka et al., 2013, p. 25).

In addition, scoliosis is more common in women than in men. According to the American Academy of Orthopedic Surgery, idiopathic scoliosis is ten times more common in girls than in boys at the age of ten. Idiopathic scoliosis, most common among children aged 11 years and older. Girls suffer from this type of scoliosis more often than boys.

Although boys and girls develop mild scoliosis at about the same rate, girls are much more likely to have a worsening curvature requiring treatment. Since a girl receives a scoliosis diagnosis, her posture curvature is up to eight times more likely to worsen than a boy's. In general, women tend to be affected more severely than men by about four times (Negrini et al., 2018).

Kudryashova et al. (2021) studied gender differences in the formation of development and correction of morphological asymmetries in children and adolescents involved in recreational swimming. It was found that for children aged 6-7 years, the asymmetry of the posture in boys and girls does not have significant differences. In addition, the morphometric parameters of adolescents with posture disorders have previously been quite successfully determined without taking into account the gender of patients and have been recognized as valid (Romanchuk, & Ganitkevich, 2022).

Results of rehabilitation

A weighty argument regarding the correctness of this study is the positive results of the experiment based on a physical rehabilitation program specially designed to prevent and reduce the asymmetry of the posture of first graders. Since the effectiveness of the program was previously proven by the practice of physical education of first grade students, the correctness and effectiveness of the indicator developed in the study can be considered proven (Bodnarchuk, & Bas, 2014). Indeed, according to expectations, the value of the proposed spine curvature index in the main group during the academic year significantly decreased (p=0,02) than the corresponding value in the comparison group (p=0,05).

A rhombus or an ordinary quadrilateral?

The terms "Moshkov rhombus" (Ali et al., 2021) or "Moshkov diamond" (Prokopiev et al., 2021) are not correct geometric definitions regarding the Moshkov test for asymmetry of the human spine, because a quadrilateral is not necessarily a rhombus. A rhombus is a quadrilateral with equal sides. The geometric figure in the Moshkov test is an ordinary quadrilateral, which in a particular case can be a rhombus, although this is unlikely.

Further research

The division of patients into a correlation field with relative values of indicators of scoliotic curvature of the spine (X_1 – morphological asymmetry and X_2 – functional asymmetry) requires further

study. There were 12 students with results below the average on the Moshkov test (less than one hundred points) and, accordingly, 22 students with results above the average (more than one hundred points). The same distribution of students (12 and 22) also appeared in the results of the left-right torso test (see Figure 3). The randomness of such a coincidence looks rather low. This phenomenon, perhaps, should be studied, taking into account the bimodal distribution law, which can obey both indicators – morphological and functional.

Conclusion

The main result of this study is an improved model of the indicator of body asymmetry in the frontal plane, equal to half the sum of the absolute values of the difference between the pair of upper and pair of lower sides of the Moshkov rhombus. The value of the proposed index of curvature of the spine in the main group during the academic year decreased significantly more (p=0,02) than the corresponding value in the comparison group (p=0,05). This indicator made it possible to increase the validity of the Moshkov test, since it simultaneously took into account data on the curvature of the spine in both the upper and lower parts of the body.

Author's contribution

Conceptualization, I.Z.; methodology, I.Z.; check, I.Z.; formal analysis, I.Z.; investigation, I.Z.; data curation, O.B.; writing – rough preparation, L.Z.; writing – review and editing, L.Z.; supervision, I.Z.; project administration, I.Z. All authors have read and agreed with the published version of the manuscript.

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Conflicts of Interests

The authors declare no conflict of interest.

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References

Ali, M.A., Prokopev, N.Yu., & Khristov, V.V. (2021). Moshkov's rhombus in evaluating the functional load on the spine of boys in the national road racing team of Syria. *Nauka Yevropi*, 85, 11-16. http://bit.ly/3WC98vg

Bodnarchuk, S., & Bas, O. (2014). Physical rehabilitation of younger schoolchildren with scoliosis. *Fizychna kultura, sport i zdorovia*, 17, 630-636

Fadzan, M., & Bettany-Saltikov, J. (2017). Etiological theories of adolescent idiopathic scoliosis: past and present. *Open Orthopaedics Journal*, 11, 1466-1489. https://doi.org/10.2174/1874325001711011466

Konieczny, M.R., Senyurt, H., & Krauspe, R. (2013). Epidemiology of adolescent idiopathic scoliosis. *Journal of Children's Orthopaedics*, 7(1), 3-9. https://doi.org/10.1007/s11832-012-0457-4

Kudryashova, Yu.A., Saburova, S.S., Berdichevskaya, Ye.M., Polovnikova, M.G., & Kudryashov, Ye.A. (2020). The role of functional and morphological asymmetry in the formation of posture disorders and their consideration in the organization of physical therapy classes. *Fizicheskaya kultura i sport – nauka i praktika*, 1, 73-79. https://doi.org/10.53742/1999-6799_2020_01_73

Kudryashova, Yu.A., Zavodnova, Ye.K., Kudryashov, M.E., Polovnikova, M.G., & Mayakova, O.V. (2021). Gender differences in the formation of posture and the correction of morphological asymmetries in children and adolescents involved in recreational swimming. *Fizicheskoe vospitanie, sport – nauka i praktika*, 1, 70-76. http://bit.ly/3Wm3IVS

Ministry of Education and Science of Ukraine (2016). Curriculum for primary school (grades 1-4). Physical Education. http://bit.ly/3jmMRDL

Negrini, S., Donzelli, S., Aulisa, A.G., Czapowski, D., Scheiber, S., de Mauroy, J.C., Diers, H.t, Grivas, T.B., Knott, P., Kotwicki, T., Lebel, A., Marti, C., Maruyama, T., O'Brien, J., Price, N., Parent, E., Rigo, M., Romano, M., Stikeleather, L., Wynne, J., & Zaina, F. (2018). 2016 SOSORT guidelines: orthopedic and rehabilitation treatment of idiopathic scoliosis during growth. *Scoliosis and Spinal Disorders*, 13(3). https://doi.org/10.1186/s13013-017-0145-8

Polka, N.S., Kalynychenko, I.O., Hozak, S.V., Stankevych, T.V., Parats, A.M., Yelyzarova, O.T., Diachenko, Yu.L., Skyba, O.O., Verbenko, M.M., Kyselevska, V.P., & Filonenko, O.O. (2013). *Systema profilaktychno-ozdorovchykh zakhodiv z pidhotovky ditei starshoho doshkilnoho viku do navchannia u zahalnoosvitnikh navchalnykh zakladakh* [Guidelines]. Ministry of Health of Ukraine, National Academy of Medical Sciences of Ukraine, Ukrainian Center for Scientific Medical Information and Patent and Licensing Work, Kyiv. https://bit.ly/3Wil2uI

Prokopev, N.Yu., Kolunin, Ye.T., Rechapov, D.S., Barangin, O.V., Borisov, S.A., & Gurtovoi, Ye.S. (2021).

Moshkov's rhombus as an indicator of the posture of boys of the second childhood period at the initial stage of martial arts. *Meditsinskaya nauka i obrazovanie Urala*, 22(1), 61-65. https://doi.org/10.36361/1814-8999-2021-22-1-61-65

Romanchuk, O. & Ganitkevich, V. (2022). Influence of yumeiho therapy on morphometric parameters of adolescents with postural disorders. *Physical rehabilitation and recreational health technologies*, 7(2), 43-47. https://doi.org/10.15391/prrht.2022-7.10

Singhal, R., Perry, D.C., Prasad, S., Davidson, N.T., & Bruce, C.E. (2013). The use of routine preoperative magnetic resonance imaging in identifying intraspinal anomalies in patients with idiopathic scoliosis: a 10-year review. *European Spine Journal*, 22(2), 355-359. https://doi.org/10.1007/s00586-012-2538-y

Tan, H., Shen, J., Feng, F., Zhang, J., Wang, H., Chen, C. & Li, Z. (2018). Clinical manifestations and radiological characteristics in patients with idiopathic syringomyelia and scoliosis. *European Spine Journal*, 27(9), 2148-2155. https://doi.org/10.1007/s00586-018-5679-9

Watanabe K, Michikawa T, Yonezawa I, Takaso M, Minami S, Soshi S. et al., (2017). Physical activities and lifestyle factors related to adolescent idiopathic scoliosis. *Journal of Bone and Joint Surgery – Series A*, 99(4), 284-294. https://doi.org/10.2106/JBJS.16.00459

Zanevskyy, I., & Bodnarchuk, O. (2020). A model of pedometer determined physical activity in the primary school children. *Theory and methods of physical education*, 20(1): 18-24. https://doi.org/10.17309/tmfv.2020.1.03

Zanevskyy, I., & Zanevska, L. (2019). Validity of the Dickson index regarding primary school physical education. *Human Movement*, 20(2), 44-49. https://doi.org/10.5114/hm.2019.81021

Zanevskyy, I., Chodinow, W., & Zanevska, L. (2019). Validity of testing and training using the kayak ergometer. *Pedagogics, psychology, medical-biological problems of physical training and sports*, 23(6), 318-324. https://doi.org/10.15561/18189172.2019.0607

Zanevskyy, I., Janiszewska, R., & Zanevska, L. (2017). Validity of Ruffier test in evaluation of resistance to the physical effort. *Journal of Testing and Evaluation*, 45(6), 2193-2199. https://doi.org/10.1520/JTE20160380

Zatsiorskii, V.M. (1982). *Sportivnaya metrologiya*. Fizicheskaya kultura i sport, Moscow.

Zezhang, Z., Sha Shifu, C.C., Chu, W., Yan, H., Xie, D., Liu, Z., Sun, X., Zhu, W., Cheng, J.C.Y., & Qiu, Y. (2016). Comparison of the scoliosis curve patterns and MRI syrinx cord characteristics of idiopathic syringomyelia versus Chiari I malformation. *European Spine Journal*, 25(2), 517-525. https://doi.org/10.1007/s00586-015-4108-6