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Original Article

Posture and physical fitness in five year-old children

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Abstract:
Introduction: Preschool phase, particularly its second stage, is important for the development of posture. At ages of 5-6, significant changes occur in the spinal and trunk structure, correlating with developmental shifts and alterations in lifestyle. The onset of mandatory schooling. sedentary habits, and decreased physical activity can potentially negatively affect the health, physical well-being, and child's posture. The aim of this study was to evaluate the relationship between the quality of body posture and the level of fitness and coordination abilities of children at the age of 5 years. A total of 414 children aged 5 years participated in the study, 178 girls and 236 boys. Body posture was examined using Mora 4G-HD medical apparatus, taking into account the parameters characterising spinal and trunk alignment and frontal alignment. The qualitative evaluation in the anteroposterior plane was performed using Wolanski's criteria, modified by Zeyland-Malawka, and in the frontal plane in accordance with the normative values developed by Suzuki et al. The child's level of physical fitness was characterised from the results of Sekita's Physical Fitness Test for Preschoolers, and the TGMD II Large Motor Test was used for assessing coordination abilities. The majority of the five-year-olds studied had normal body posture. At this stage of development, no clear differences were found in the level of fitness and coordination abilities between children with normal posture and those with postural defects. The quality of body posture of children aged 5 years did not significantly differentiate the level of physical fitness and the coordination abilities being studied.
Key words: body posture, physical fitness, boys and girls, preschool age

Introduction

Preschool age is a period of harmonious morphological development. At this time, however, there are great differences between individual children in the level of development and the rate of growth, which leads to the formation of an appropriate somatotype around the age of 5.The maturation of the central nervous system and improvements in its functioning foster the development of sensorimotor integration and motor skills (Plandowska, Lichota, Górniak, 2019). The biological need to move is characteristic for the preschool child. Hyperactivity is a natural stimulator of physical, motor and cognitive development. The child reveals considerable coordination abilities in the whole body, but has problems performing precise movements. Preschool-age children actively engage in diverse physical activities. Through play, games, and physical exercises, they develop skills such as walking, running, jumping, throwing, and catching. Physical movement serves not only as a form of entertainment for them but also as a tool for exploring and understanding the world. At preschool age, sexual dimorphism in the structure of the body, its proportions and motor activity all become apparent, and health habits are formed that are important for future quality of life.

One of the positive indicators of a child's health and physical development is body posture. At preschool age, this posture is very labile, characterized by poorly formed physiological curvatures of the spine and a significantly extended abdomen. In the standing position, the lower limbs are straightened, but during complex locomotor movements small physiological flexion contractures are observed. Through appropriate exercises and physical activity, it is possible to support proper body posture and prevent potential irregularities.

In many studies, the authors indicate the risk factors to the forming the musculoskeletal system of a preschool child, which most often include developmental disharmony and low levels of physical activity. However, it should be noted that regular physical activity in preschool age not only influences physical fitness but also contributes to the overall development of the child. It enhances blood circulation, has a positive impact on the respiratory system, and supports the development of muscles and bones. Despite considerable interest among researchers in the development and fitness of preschool-aged children, the literature still lacks a substantial number of studies on this subject. However, few studies describe physical fitness in terms of the structure and posture of a young child (Wasiluk, Saczuk, Górniak, Lichota, 2023).
This situation is related to the dynamics of developmental changes in preschool children and the lack of current, precisely defined physiological norms and criteria for evaluating both posture and fitness levels (Sołtysiak, Kociuga, 2017; Hawke, Romez, Evans, 2016; Sedrez, da Rosa, Noll, Medeiros da Silva, Candotti, 2015).

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Therefore, it is challenging to determine the extent to which the body posture of preschool children correlates with their overall physical fitness. Understanding these relationships may be crucial for both the development of minors, their educational processes, and the implementation of preventive measures.
Authors in a number of studies point to the deterioration of posture with the age of children and show the need for early preventive and corrective measures using healthy forms of physical activity (Balko et al. 2017, Romanova et al. 2022). Therefore, it is important that the preschool years, defined as the age of play, be fully utilized for the formation of correct habits of upright posture maintenance and comprehensive strengthening of the musculoskeletal apparatus, and thus prepare the young body for compulsory schooling.

The aim of this study was to assess the relationship between postural quality and the level of physical fitness of five-year-old children.

Material & methods

Participants

The study used the results of 414 preschoolers (mean age: 5.2 range: 4.7-5.9), 236 boys and 178 girls, who participated in all measurements of posture assessment and physical fitness tests. The study was carried out in 2015 as part of the project entitled "Psychophysical development of Biala five-year-olds" (Górniak ed. 2017), in accordance with the Declaration of Helsinki guidelines, after obtaining a positive opinion from the Senate Committee on Research Ethics (SKE 01-01/2014).

Healthy children born in 2010 participated in the project. The parents or legal guardians of these children gave their written consent to participate in the study and to use the results for scientific purposes. The exclusion criterion was the absence of the child on the day of the study, ill-health or unwillingness of the child to participate in the tests and measurements, and withdrawal of parental consent during the project.
Evaluation of the motor system was conducted in the Posture of the Body laboratory of the Regional Research and Development Centre, while fitness tests took place in the athletics hall of the Faculty of Physical Education and Health in Biala Podlaska.

Measure

Body posture was assessed using the photogrammetric method based on projection moiré, performed using model Mora 4G-HD medical apparatus from CQ Elektronik System (Świerc, 2022).
In the qualitative assessment of the body posture in the anteroposterior plane, measurements of the spine inclination angles in the lumbar-sacral (angle α), thoracolumbar (angle β) and upper thoracic (angle γ) sections were used to assess the size of the thoracic kyphosis (KP) and lumbar lordosis (LL) and then to calculate the value of the compensation index (MI) in order to determine the children's body posture type (Górniak, Lichota, 2023).

Normal postures included: balanced posture I and II, kyphotic I and lordotic I, abnormal postures: kyphotic II and III, balanced III and lordotic II and III.
To characterise the body posture in the frontal plane, the Posterior Trunk Symmetry Index (POTSI) was calculated (Kotwicki, Kinell, Chowańska, Bodnar-Nanuś, 2008). Based on the normative values developed by Suzuki et al. (Suzuki, Inami, Ono, Kohno, Asher, 1999), cases in which the value of the POTSI index remained at or above 27 were classified as abnormal. Measurements of height and weight were used to calculate the BMI value, which describes the children's somatic build.

The level of the children's motor development was assessed using the results of tests of fitness and coordination skills. Sekita's Physical Fitness Test for Preschoolers (Suder, Sobiecki, Kościuk, Pałosz, 2002) and TGMD II Large Motor Test (Urlich, 2000) were conducted, in which the technique of performing exercises carried out as part of locomotor ability tests and the ability to use equipment were evaluated with points.

Data analysis

In the groups of boys and girls, arithmetic means and standard deviation were calculated for all measurable parameters under study, indicating their extreme values. The Student's t-test was used to determine the significance of differences for independent samples. The significance level was taken to be $p \leq 0.05$. General performance (PF) was determined as the average of all TGMD II test scores. The individual results on the Sekita test attempts were normalised on a T scale to the mean and spread measures of all subjects (Przewęda, Dobosz, 2005).

Results

Poorly accentuated physiological curvatures of the spine were characteristic of the posture of five-year-old children. Among the children examined, the angles of particular spine sections reached zero values, which resulted in pronounced flattening of thoracic kyphosis and lumbar lordosis.

In the children, the most frequent postures were kyphotic (44.2%); balanced postures (36.0%) were less frequent, and the least frequent were lordotic postures (19.8%).
Taking into account the Zeyland-Malawka criteria and the values of the POTSI index (Kotwicki et. al., 2008), a group of children with normal (PP) and abnormal posture (PN) was distinguished. It should be noted that among the 5-year-olds with postural defects who were examined, changes in the alignment of the spine and trunk in one or two planes were observed (Table 1).

Table 1. Spinal position in the sagittal and the frontal plane and qualitative assessement of posture

	boys (n 236)		girls (n 178)	
	mean ± SD	R	mean ± SD	R
Lumbosacral inclination (angle α)	8.20 ± 3.90	0.00 – 19.10	8.90 ± 3.70	0.00 – 19.30
Pectoral-lumbar inclination (angle β)	7.70 ± 2.90	0.00 – 19.50	8.40 ± 3.20	0.00 – 17.00
Upper thoracic slope (angle γ)	10.40 ± 3.40	0.00 – 18.90	10.20 ± 3.60	0.00 – 25.10
Size of thoracic kyphosis	18.00 ± 4.70	6.20 – 30.50	18.60 ± 5.00	4.70 – 34.20
Size of lumbar lordosis	15.80 ± 5.20	4.60 – 28.80	17.40 ± 5.10	2.30 – 31.40
MI index	2.20 ± 5.40	(-15.10) – 14.30	1.30 ± 5.90	(-14.60) – 14.90
POTSI index	19.00 ± 8.60	2.90 – 44.20	17.90 ± 8.40	3.40 – 42.80
Qulitative assessement of posture				
	n	%	n	%
Correct body posture (PP)	164	69,5	130	73,0
Incorret body posture (PN)	72	30,5	48	27,0

n - number of groups; R – range; SD - standard deviation

These results indicate that the differences in basic somatic traits and BMI between the groups being evaluated were small and statistically insignificant. Boys and girls with incorrect posture had slightly higher values for height and body mass in relation to their peers with correct posture. In terms of the motor abilities studied here, no significant distances were found between the groups assessed. Boys with correct body posture achieved slightly better results on speed and lower limb explosive strength tests, while girls achieved slightly better results on strength tests (Table 2).

Table 2. Values of somatic features and results of motor ability tests in children with correct (PP) and incorrect (PN) posture

Sequence of tests	boys			girls		
	PP (n 164)	PN (n 72)	Test	PP (n 130)	PN (n 48)	Test
	mean ± SD	mean ±SD	t	mean ± SD	mean ± SD	t
Body height	114.92±4.95	115.03±5.11	0.15	113.30±4.26	113.76±5.66	0.59
Body mass	20.75±3.50	20.91±3.26	0.32	19.91±2.91	20.67±3.36	1.48
BMI	15.64±1.84	15.74±1.65	0.40	15.47±1.68	15.90±1.76	1.5
SBJ	91.09±21.50	91.01±21.47	0.03	94.45±23.46	91.08±23.06	0.85
4x5mSR	10.35±1.17	10.57±1.33	1.32	10.54±1.22	10.30±1.39	1.11
20mR	5.83±0.79	5.74±0.73	0.78	5.85±0.86	5.78±0.70	0.50
1 kg TB	204.50±52.37	210.36±64.30	0.74	205.19±56.26	202.54±62.27	0.27
PF	50.21±6.67	49.79±8.15	0.41	49.72±7.45	50.18±8.00	0.36

* p≤ 0.05;

PP – correct body posture; PN – incorrect body posture; SD - standard deviation

On the basis of the sum of the locomotor ability scores, it was found that better results were obtained by children with correct posture, while the results of individual tests remained at different levels. Only in the running test did girls with incorrect posture achieve significantly better results compared to girls with correct posture. As far as the skills of controlling the device are concerned, slightly better results were obtained by children with incorrect posture, with the exception of the overhead throw test (boys), striking a stationary ball and catching the ball (girls). Statistically significant differences (p≤ 0.05) were found in the underhand roll test (Table 3).

Table 3. Test rezus of motor skills and coordination skills test in children with correct (PP) and incorrect (PN) posture

Sequence of tests	boys			girls		
	PP (n 164)	PN (n 72)	Test t	PP (n 130)	PN (n 48)	Test t
	mean ± SD	mean ± SD		mean ± SD	mean ± SD	
Motor Skills Test						
Run	6.41±2.00	6.58±1.79	0.62	6.56±1.65	6.00±1.65	2.01*
Gallop	5.35±2.22	4.92±2.31	1.37	5.42±2.16	4.85±2.71	1.43
Hop	5.41±2.64	5.69±2.61	0.75	6.34±2.17	6.27±2.07	0.19
Leap	4.70±1.54	4.79±1.47	0.42	4.48±1.64	4.69±1.24	0.78
Slides	5.70±1.94	5.17±2.21	1.85	5.62±2.04	4.96±2.40	1.84
Horizontal jump	5.95±2.25	5.92±2.29	0.09	6.02±2.21	6.00±2.01	0.04
Total	33.52±8.01	33.07±8.08	0.40	34.44±7.12	32.77±6.42	1.42
Coordination Test						
Striking a stationary ball	7.17±2.27	8.32±1.63	3.87	6.82±2.08	6.31±2.17	1.41
Stationary dribble	4.02±2.99	4.36±2.81	0.81	3.83±2.59	4.33±2.85	1.12
Catch	4.33±1.49	4.42±1.52	0.41	4.49±1.36	4.40±1.63	0.40
Kick	6.36±1.75	6.53±1.43	0.71	5.08±1.82	5.54±1.97	1.45
Overhead throw	5.97±1.66	5.75±1.40	0.98	5.38±1.49	5.71±1.43	1.3
Underhand roll	4.73±1.89	4.90±1.48	0.68	4.54±1.60	5.25±1.67	2.61*
Total	32.59±7.52	34.28±5.84	1.7	30.15±5.61	31.54±5.90	1.45

* p≤ 0.05

PP – correct body posture; PN – incorrect body posture; SD - standard deviation

Dicussion

These results indicate the presence of normal posture in the majority of the five-year-olds who were studied. Our findings correspond with those of studies of children from the eastern regions of Serbia (Jorgič, Milenkovič, Ždrale, Milenkovič, Stankovič, Bubanj, 2015) and also Slovakia (Koralova, 2018). These authors indicated a large variation in posture. On the other hand, the results obtained by Maciałczyk-Paprocka et al. (2011) and Wojna et al. (2010) indicate a much more frequent occurrence of posture defects in Poznań children aged 3-6 years.

In our observations, kyphotic postures with a weakly accentuated thoracic curvature were most frequently found, while equivalent postures were less frequent, and lordotic type postures were the least frequent. Soltysiak & Kociuga (2017), Wojna et al. (2010) and Jorgić et al. (2015) all found that lordotic postures were most common in children aged 5-6 years. Lafond et al. (2007), studying Canadian children, observed marked changes in anteroposterior spinal curvatures towards their deepening.

In a study of five-year-olds from Biała Podlaska, no significant differences were found in the children's body composition depending on the quality of their posture. Similar observations were made by Maciałczyk-Paprocka et al. (2011).

In many papers, authors draw attention to the importance of physical activity in shaping the musculoskeletal system and conditioning motor skills or fitness (Kit, Akinbami, Isfahani, Ulrich, 2012; Webster, Martin, Staiano, 2019). Dimorphic determinants of the level of motor skills and abilities were addressed in works by Aye et al., (2018), Niemistö et al., (2019); and Saczuk & Wasiluk (2021). The negative effect of overweight and obesity on the level of motor skills of preschoolers was observed by Morano et al., (2011), Castetbon & Andreyeva (2012), Robinson et al., (2015), Jiang et al., (2018), Plandowska, et.al., (2019), and no effect of body mass size on TGMD outcomes by Kit et al., (2012). The place of residence has also been found to differentiate the level of physical fitness and large motor skills of preschool children (Niemistö et.al., 2019; Valentini, 2012). Furthermore, it has been reported that the level of children's fine motor skills have been associated with time spent in front of a TV or computer screen (Webster et. al., 2019). However, there are few studies dedicated to preschool children in which large motor skills and physical fitness are assessed in relation to the postural defects present. Jagucka-Mętel et al. (2013) found that lower limb defects significantly reduce children's motor skills. In contrast, defects in the shoulder and thoracic girdle had no effect on the physical fitness of young children. On the other hand, Wasiluk et al. (2023) did not observe statistically significant differences in the level of physical fitness between 5-year-olds with normal and abnormal foot arches. However, a tendency towards a higher level of overall fitness was noted in the group of children with abnormal foot arches. During the assessment of somatic features, BMI and motor abilities in our study, no significant differences were found between the groups assessed according to the posture criterion. This situation may be explained by the fact that a 5-year-old child is at the beginning of his/her motor development path, thus differences in the level of motor skills, locomotor skills and instrument-control skills in individual posture groups may be small. Barros et al. (2022) demonstrated that abnormal posture in childhood can have an adverse effect on a child's motor development. Our observations on large motor skills showed that girls and boys with normal posture performed slightly better. On the other hand, in instrument control skills, preschoolers with abnormal body posture had better results. It should be emphasized that the relationships between body posture and physical fitness are multifaceted. Therefore, a holistic approach to child development should encompass both the cultivation of proper body posture and the enhancement of physical fitness. Both of these aspects are crucial for the correct development of children. Experts consistently underscore that the first five years of a child's life are pivotal for forming fundamental health habits. Special attention should be paid to this period, as it is during this time that habits are shaped that can significantly impact the health and functioning of the child in the future life (Šišková et al., 2020; Timpel et al. 2021; Łabęcka et al., 2021; Paulysnara de Oliveira et al., 2015).

Conclusions

1. The examined children most frequently exhibited a kyphotic posture with a weakly emphasized curvature of the chest, less commonly an equivalent posture, and least frequently a lordotic posture.
2. In the studies of five-year-olds from Biała Podlaska, no significant differences were observed in the body composition of children based on the quality of their posture.
3. Girls and boys with a correct body posture achieved slightly better results in gross motor skills. However, in terms of instrument control skills, preschoolers with an incorrect body posture demonstrated superior performance.
4. Early identification and intervention in the case of potential irregularities in body posture and physical fitness may contribute to their correction and improvement, thereby minimizing potential health consequences for the child.

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References:

Aye, T., Kuramoto-Ahuja, T., Sato, T., Sadakiyo, K., Watanabe, M., & Maruyama, H. (2018). Gross motor skill development of kindergarten children in Japan. *Journal of PhysicalTtherapy Science*, *30*(5), 711–715. https://doi.org/10.1589/jpts.30.711

Balko, S., Balko, I., Valter, L., Jelinek, M. (2017). Influence of physical activities on the posture in 10-11 year old schoolchildren. *Journal of Physical Education and Sport.* 17(1), 16, 101 – 106. https://efsupit.ro/images/stories/01feb2017/art%2016.pdf

Barros, W. M. A., da Silva, K. G., Silva, R. K. P., Souza, A. P. D. S., da Silva, A. B. J., Silva, M. R. M., Fernandes, M. S. S., de Souza, S. L., & Souza, V. O. N. (2022). Effects of Overweight/Obesity on Motor Performance in Children: A Systematic Review. *Frontiers in Endocrinology*, *12*, 759165. https://doi.org/10.3389/fendo.2021.759165

Castetbon, K., & Andreyeva, T. (2012). Obesity and motor skills among 4 to 6-year-old children in the United States: nationally-representative surveys. *BMC Pediatrics*, *12*, 28. https://doi.org/10.1186/1471-2431-12-28

Górniak, K. (red.) (2017). Psychophysical state of 5-year-olds from Biala Podlaska. *Faculty of Physical Education and Sport in Biała Podlaska, Józef Piłsudski University of Physical Education in Warsov*. [in Polish]

Górniak, K., Lichota, M. (2023). Measurement and descriptive characteristics of posture and foot arches in five-year-old children. *Faculty of Physical Education and Health in Biala Podlaska, Józef Piłsudski University of Physical Education in Warsov*. [in Polish]

Hawke, F., Rome, K., & Evans, A. M. (2016). The relationship between foot posture, body mass, age and ankle, lower-limb and whole-body flexibility in healthy children aged 7 to 15 years. *Journal of Foot and Ankle Research*, *9*, 14. https://doi.org/10.1186/s13047-016-0144-7

Jagucka-Metel, W., Brzeska, P., Sokołowska, E., Baranowska, A., Weber-Rajek, M., Sobolewska, E., & Machoy-Mokrzyńska, A. (2013). Evaluation of physical fitness in children of pre-school age including postural problems. *Annales Academiae Medicae Stetinensis*, *59*(2), 129–132.

Jiang, G. P., Jiao, X. B., Wu, S. K., Ji, Z. Q., Liu, W. T., Chen, X., & Wang, H. H. (2018). Balance, Proprioception, and Gross Motor Development of Chinese Children Aged 3 to 6 Years. *Journal of Motor Behavior*, *50*(3), 343–352. https://doi.org/10.1080/00222895.2017.1363694

Jorgič, B., Milenkovič, M., Ždrale, S., Milenkovič, S., Stankovič, R., & Bubanj, S. (2015). Spinal cord posture in the sagittal plane among young schoolchildren residing in the area of Knjażevc. *Facta Universitis – Physical Education and Sport*, 13, 2311-318.

Kit, B. K., Akinbami, L. J., Isfahani, N. S., & Ulrich, D. A. (2017). Gross Motor Development in Children Aged 3-5 Years, United States 2012. *Maternal and Child Health Journal*, *21*(7), 1573–1580. https://doi.org/10.1007/s10995-017-2289-9

Koralova, M. (2018). Postural state of preschoolers on territory of Ružomeberok and Martin Slovakia. SHS Web of Conferences, 51, 02004. https://do.org/10.1051/shsconf/20185102004

Kotwicki, T., Kinel, E., Chowańska, J., & Bodnar-Nanuś, A. (2008). POTSI, Hump Sum i Suma Rotation – new surface topography parameters for evaluation of scoliosis deformity of the trunk. *Polish Journal of Physiotherapy*, 3(4), 8, 231-240.

Lafond, D., Descarreaux, M., Normand, M.C., & Harrison, D.E. (2007). Postural development in school children: a cross-sectional study. *Chiropractic & Osteopathy*, 15,1. https://pmclegacy.ncbi.nlm.nih.gov/pmc/articles/PMC1781952

Łabęcka, M. K., Górniak, K., & Lichota, M. (2021). Somatic determinants of changes in selected body posture parameters in younger school-age children. *PeerJ*, *9*, e10821. https://doi.org/10.7717/peerj.10821

Maciałczyk-Paprocka, K., Krzyżniak, A., Kotwicki, T., Kałużny, Ł., Przybylski, J. (2011). The body posture of preschool children. *Problems of Hygiene and Epidemiology,* 92(2), 86-290. [in Polish]

Morano, M., Colella, D., & Caroli, M. (2011). Gross motor skill performance in a sample of overweight and non-overweight preschool children. *International Journal of Pediatric Obesity: IJPO : an official Journal of the International Association for the Study of Obesity*, *6 Suppl 2*, 42–46. https://doi.org/10.3109/17477166.2011.613665

Niemistö, D., Finni, T., Haapala, E. A., Cantell, M., Korhonen, E., & Sääkslahti, A. (2019). Environmental Correlates of Motor Competence in Children-The Skilled Kids Study. *International Journal of Environmental Research and Public Health*, *16*(11), 1989. https://doi.org/10.3390/ijerph16111989

Nielsen, C., Gutierrez-Farewik, E. M., Hirschfeld, H., & Saraste, H. (2008). Seat load characteristics in children with neuromuscular and syndrome-related scoliosis: effects of pathology and treatment. *Journal of Pediatric Orthopedics. Part B*, *17*(3), 139–144. https://doi.org/10.1097/BPB.0b013e3282fde471

Plandowska, M., Lichota, M., Górniak, K. (2019). Postural stability of 5-year-old girls and boys with different body heights, *Plos One,* 14(12), e0227119. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0227119

Przewęda, R., Dobosz, J. (2005). Growth and physical fitness of polish youths. *Studies and Monographs 103, Józef Piłsudski Academy of Physical Education in Warsav*. [in Polish]

Robinson, L. E., Stodden, D. F., Barnett, L. M., Lopes, V. P., Logan, S. W., Rodrigues, L. P., & D'Hondt, E. (2015). Motor Competence and its Effect on Positive Developmental Trajectories of Health. *Sports Medicine (Auckland, N.Z.)*, *45*(9), 1273–1284. https://doi.org/10.1007/s40279-015-0351-6

Romanova, E., Kolokoltsev, M., Vorozheikin, A., Baatar, B., Khusman, O., Purevdorj, D., Garov, S., Starshova, N.,

Kiseliv, Y. (2022). Comprehensive program for flat foot and posture disorders prevention by means of physical education in 6-year-old children. *Journal of Physical Education and Sport.* 22(11), 337, 2265-2662.

Saczuk, J., & Wasiluk, A. (2021). Assessment of the relationship between fitness abilities and motor skills of 5-year-olds by taking into account dimorphic differences. *Journal of Physical Education and Sport*, 21(1),115-121. https://doi.org/10.7752/jpes.2021.01016

Sedrez, J. A., da Rosa, M. I., Noll, M., Medeiros, F.daS., & Candotti, C. T. (2015). Risk factors associated with structural postural changes in the spinal column of children and adolescents. *Revista Paulista de Pediatria*, *33*(1), 72–81. https://doi.org/10.1016/j.rpped.2014.11.012

Suder, A., Sobiecki. J., Kościuk. T,. & Pałosz, J. (2002) Motor efficiency and body posture pre-school children. *Medical News*, 71, 4-5, 230-235. [in Polish]

Šišková, N., Grznárová, T., Baranová, P., & Vanderka, M. (2020). Effect of theTGMD-2-based physical activity on the motor skills of healthy children and children with autism spectrum disorder at an earlier school age. *Journal of Physical Education and Sport*, 20(5), 2574-2579. https://doi.org/10.7752/jpes.2020.05351

Sołtysiak, K., & Kociuga, N. (2017). Assessment of Body Posture in children of Kindergarten Age. *Polish Journal of Physiotherapy*, 2,17, 82-99.

Suzuki, N., Inami, K., Ono, T., Kohno, K., & Asher, MA. (1999). Analysis of posteriori trunk symmetry index (POTSI) in scoliosis, part 1. *Studies in Health and Technology Informatics*, 59, 81-84.

Świerc, A. (2022). Specialized electronic systems for medicine picture diagnostics. Czernica Wrocławska: CQ Electronic System. http://www.cq.com.pl./eindex.html

Timpel, P., Herrmann, S., Flößel, P., Beck, H., & Schwarz, P. E. (2021). Effectiveness of digital primary prevention interventions targeting physical activity, motor skills and nutrition in children aged 3-10 years in the setting of day care and primary school: protocol for a systematic review. *BMJ open*, *11*(12), e053628. https://doi.org/10.1136/bmjopen-2021-053628

Urlich, D.A. (2000). Test of Gross Motor Development (2nd ed.) Austin, TX:Pro-Ed.

Valentini N. C. (2012). Validity and reliability of the TGMD-2 for Brazilian children. *Journal of Motor Behavior*, *44*(4), 275–280. https://doi.org/10.1080/00222895.2012.700967

Wasiluk, A., Saczuk, J., Górniak, K., & Lichota, M. (2023). Foot arches and physical fitness of 5-year-old children. *Journal of Education, Health and Sport*. 13 (3), 140-146.

Webster, E. K., Martin, C. K., & Staiano, A. E. (2019). Fundamental motor skills, screen-time, and physical activity in preschoolers. *Journal of Sport and Health Science*, *8*(2), 114–121. https://doi.org/10.1016/j.jshs.2018.11.006

Wojna, D., Anwajler, J., Hawrylak, A., & Barczyk, K. (2010). Photogrammetric method in evaluation of constitution and the body posture in preschool children. *Physiotherapy,* 18,4, 7-39.