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Postural dysfunction indicators of pre-school children from the Polish population in the COVID-19 post-pandemic period

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
E Funds Collection

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Abstract

Background & Study Aim: Posture, it goes without saying, is an extremely important aspect in a child's development. Despite the many positive effects of advances in technology, limitations on the physical activity of the youngest children are emerging to a considerable extent The aim of this study is the knowledge about the posture of pre-school children, based on the case of a 60,000-person city in Poland during the ending phase of COVID-19 pandemic.

Material & Methods: Sixty children aged 5-6 years (30 girls, 30 boys) from Public Kindergarten No. 2 in Łomża, Poland (a medium-sized city of more than 60,000 inhabitants) were studied during the 2021/2022 post-pandemic school year. The posture examination was based on Kasperczyk's limited visual scoring method. BMI was calculated, classifying children into three categories: deficiency, norm, excess.

Results: Ten sets of postural dysfunctions and eight subsets were found among the pre-schoolers studied – a total of 245, including 141 in girls and 104 in boys. The most common defect was asymmetric and/or protracted shoulder positioning (65% of the children studied). Girls predominated (25, representing 41.67% of the study sample and 83.33% of the total girls). These proportions, concerning the 14 boys, are respectively: 23.33% and 46.66%. The difference in proportions is statistically significant ($p<0.05$).

Conclusions: There is no basis for concluding that COVID-19 pandemic significantly increased postural defects among 5-6 year-old pre-schoolers. The extended analysis of the phenomenon of postural defects and associated with BMI indices shows the prospect of further exploration based on a complementary approach. We consider it necessary to enrich this research with elements of estimating the physical fitness of the subjects along with their daily and weekly physical activity and diet quality. In our opinion, such knowledge should form the basis for the development of individualised intervention programmes.

Keywords: asymmetric shoulder positioning • BMI • physical activity • protracted shoulder positioning

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Physical activity – *noun* exercise and general movement that a person carries out as part of their day [39].

Body mass index *noun* – an index that expresses adult weight in relation to height, calculated as weight in kilograms divided by height in metres squared. Abbreviation **BMI** (note: a body mass index of less than 25 is considered normal, and one of over 30 implies obesity) [30].

Cardiovascular – *adjective* relating to the heart and the blood circulation system [30].

INTRODUCTION

Posture, it goes without saying, is an extremely important aspect in a child's development. However, under the influence of the intensely changing conditions and lifestyles of children, their posture also undergoes many changes. Despite the many positive effects of advances in technology, limitations on the physical activity of the youngest children are emerging to a considerable extent [1]. The main drawback of children's modern lives is a sedentary lifestyle. It is well known that a reduction in physical activity at the developmental age leads to disorders in the process of posturogenesis, a decrease in fitness and eye-hand coordination in the forming young child's locomotor apparatus. The relatively low level of fitness and physical fitness of pre-school children in Poland and other countries raises justified concerns and prompts necessary interventions in areas of broadly understood health, including those concerning the proper development of the child [2, 3].

Children increasingly prefer to spend their leisure time in front of a computer and smartphone rather than participating in physical activities. Inadequate nutrition and lack of appropriate physical activity cause children to gain weight, which over time can result in overweight or obesity [4]. Based on a population-based study of European children in 2014, it was found that approximately 4,4 million pre-school-aged children, including 440,000 Polish children were classified as obese [5]. Furthermore, in recent years, the COVID-19 epidemic has become a major environmental factor limiting physical activity in the youngest children. In March 2020, the World Health Organisation (WHO) declared an epidemic state. National quarantines and social isolation were introduced. All education shifted to a remote learning mode, significantly limiting children's ability to enjoy healthy physical activity. The many hours spent in front of a computer in remote classes had a detrimental effect on diet, sleep hygiene and activity levels, among other things [6, 7].

A 2020 US study suggests that short-term changes associated with children's reduced physical activity and sedentary lifestyles caused by COVID-19 restrictions may be perpetuated. In the long term, it can lead to an increased risk of diabetes, cardiovascular disease, obesity and more frequent postural defects [8]. Studies indicate that smartphone addiction among children and adolescents increased significantly during and after the pandemic (an apparent increase of 53.86% [9]). Comparing the above research findings with pre-pandemic reports, there is definitely a signalling of musculoskeletal problems [10-12].

Posture is a widely understood concept. It is defined as a human characteristic, individual for each person, which is expressed by his or her silhouette. It represents a motor habit that can be corrected and shaped during a person's growth. The posture of the body depends on age, gender, lifestyle, the somatic structure of the skeletal-articular-muscular system, somatic type, mental state, sports practice and occupation [13]. The formation of posture during childhood is influenced by morphological-physiological and environmental factors. The former include, for example, the evolutionary changes that the human body underwent to overcome the force of gravity and achieve upright posture. Genetic factors also play a part in the formation of posture. A person's psycho-physical state also has an impact on posture. However, environmental factors have the greatest influence. It is the environment and living conditions that determine our posture [14, 15].

The aim of this study is the knowledge about the posture of pre-school children, based on the case of a 60,000-person city in Poland during the ending phase of COVID-19 pandemic.

MATERIAL AND METHODS

Participants

Sixty children aged 5-6 years (30 girls, 30 boys) from Public Kindergarten No. 2 in Łomża, Poland (a medium-sized city of more than 60,000 inhabitants) were studied during the 2021/2022 post-pandemic school year.

Design

The posture examination was based on Kasperczyk's [16] limited visual scoring method. Selected elements of body structure and posture were observed: (a) in the sagittal plane (head, shoulders, shoulder blades, chest, abdomen, back); (b) in the frontal plane, in a forward position (shoulders, chest, knees); (c) in the frontal plane, in a backward position (shoulders, shoulder blades, spine); (d) foot arches. Either the presence or absence of a postural defect was determined.

BMI was calculated, classifying children into three categories: deficiency, norm, excess. This qualification was based on BMI centile grids for girls and boys from 3-18 years of age, developed on the basis of the OLAF and OLAF studies of the 'Institute Pomnik-Centrum Zdrowia Dziecka' in Warsaw, Poland ('The Children's Memorial Health Institute') from 2007-2012 [17].

For the purposes of the study, a proprietary 'Child Posture Assessment Card' was created, which takes into account WHO recommendations for school-aged children and adolescents. SD values ≥1 are borderline for overweight and SD ≥2 for obesity, while in children under 5 years of age, BMI limits for the diagnosis of overweight >2 SD and obesity >3 SD of the BMI distribution of the growth standard are recommended [17].

The criterion for ordering the results of the observations is based on the number (n) and consequently the proportion (%) of cases of postural dysfunction (separation of homogeneous sets – abbreviation: SHS). In the case of equality of observations involving two or more cases, the SHS was assigned the same ranking position (RP) and the letter 'a' denotes the dataset with the higher representation in this division etc. If, within a given dysfunction, further, specific ones (subsets) are distinguished, then at this level of classification a higher representation of the empirical variables is higher. Thus, RP is the symbolic code for these SHS, some of which also contain subsets. The reference system for calculating the proportion (in %) of recorded dysfunctions is the number of children examined in each case (N = 60). Thus, if a given category of dysfunction is identified in 30 children, the SHS is 50% and if 15 girls and 15 boys are affected, it is clear that the gender subsets divide this SHS in half (each subsets = 50%). However, the gender identification of this phenomenon in relation to the child population sample concerns 25% girls and 25% boys according to the n/N formula.

In an overall analysis that takes into account the distribution of results according to the population criteria of BMI, proportions are monitored both in relation to the total children studied (N = 60) and in relation to the SHS and sex of the child.

Statistical analysis

The estimation of the results is based on the following indicators: frequency (N, n); mean (M); median (Me); minimum (Min); Maximum (Max); standard deviation (SD); lower quartile and upper quartile; significance level, probability (*p*); effect size (*z*).

The significance of differences in proportions between girls and boys was calculated for individual variables. However, for BMI, the Mann-Whitney U test was used. A test probability of $p<0.05$ was considered significant and a test probability of $p<0.01$ was considered highly significant.

RESULTS

Ten sets of postural dysfunctions and eight subsets were found among the pre-schoolers studied – a total of 245, including 141 in girls and 104 in boys. The most common defect was asymmetric and/or protracted shoulder positioning (65% of the children studied). Girls predominated (25, representing 41.67% of the study sample and 83.33% of the total girls). These proportions, concerning the 14 boys, are respectively: 23.33% and 46.66%. The difference in proportions is statistically significant ($p<0.05$). Protruding shoulder blades were observed in 61.67% of children. Also more frequent in girls (22, representing 36.67% and 73.33%). In half of the boys, the proportion is respectively: 25% and 50%. Among the half and larger proportion of postural defects found, the distribution is as follows: arching of the feet 56.67%; exaggerated lumbar lordosis 50% and positioning of the knees 50% (with genu valgum dominance and this result is consistent: 11 girls and 11 boys). One more concordance (one observation each) concerns pectus excavatum (Table 1).

The distribution of BMI was similar among girls and boys (Table 2). Population norms were met by 50% of the children studied, including 14 girls (23.33%) and 16 boys (26.67%). Underweight was observed in 26.67% of the children studied, including 14 girls and 2 boys. Excess body weight was observed in 23.33% of the children studied. The proportions are reversed: in 2 girls and 12 boys (Table 3).

Among the children studied, excessive weight favours swollen abdomen (13 total cases), the formation of exaggerated lumbar lordosis (11 cases) and genu valgum (10 cases). Among the 39 children with asymmetric and/or protracted shoulder positioning, those with a normal BMI were

Table 1. Postural dysfunctions of pre-school girls (n = 30) and boys (n = 30) in relation to the total number of subjects studied.

Separation of homogeneous sets (subsets) of all children (N = 60)							Separation of homogeneous sets (subsets) girls & boys (n/60)			
dysfunction (n/60)										
RP/ code	SHS	subset	SHS		subset		girls (n = 30)		boys (n = 30)	
			n	%	n	%	n	%	n	%
1	asymmetric and/or protracted shoulder positioning		39	**65**			25	**41.67***	14	**23.33***
2	protruding shoulder blades		37	**61.67**			22	**36.67**	15	**25**
3	arching of the feet	flat	34	**56.67**	21	**35**	12	**20**	9	**15**
		lowered			13	**21.67**	7	**11.67**	6	**10**
4a	exaggerated lumbar lordosis		30	**50**			18	**30**	12	**20**
4b	positioning of the knees	genu valgum	30	**50**	22	**36.67**	11	**18.33**	11	**18.33**
		genu varum			8	**13.33**	5	**8.33**	3	**5**
5	swollen abdomen		28	**44.67**			18	**30**	10	**16.67**
6a	head protruded forward		16	**26.67**			9	**15**	7	**11.67**
6b	formation of thoracic kyphosis	decreased	16	**26.67**	10	**16.67**	2	**3.33**	8	**13.33**
		increased			6	**10**	2	**3.33**	4	**6.67**
7	scoliosis		10	**16.67**			8	**13.33**	2	**3.33**
8	chest shape	barrel	5	**8. 83**	3	**5**	1	**1.67**	2	**3.33**
		spectus excavatum			2	**3.33**	1	1.67	1	**1.67**
Synthesis of results										
Sum RP code: 1 + 2 + 4a + 5 + 6a + 7			**160**		**girls 41**		**100**		**boys 44**	**60**
Sum RP code: 3 + 4b + 6b + 8			**85**							
sum RP code			**245**				**141**			**104**

*p<0.05

Table 2. Estimation of BMI of surveyed preschoolers (n = 60).

Indicators		Examined children (N = 60)	Gender	
			girls (n = 30)	boys (n = 30)
M		16.31	16.16	16.54
Me		15.5	15.3	16
SD		2.77	2.88	2.62
Min		13.21	13.24	13.91
Max		26.73	23.9	26.7
lower quartile		14.3	14.12	15.33
upper quartile		17	17	16.8
Mann-Whitney U test	**z**		1.339	
	p		0.181	

Table 3. Distribution of BMI due to generalised classification criteria for a population of preschool children.

Criteria for BMI classification	Proportions of indicators in examined children (N = 60)		Proportions of indicators in relations to gender			
			girls (n = 30)		boys (n = 30)	
	n	%	n	%	n	%
deficiency	16	26.67	**14/60**	**23.33**	**2/60**	**3.33**
			14/16	87.5	2/16	12.5
norm	30	50	**14/60**	**23.33**	**16/60**	**26.67**
			14/30	46.67	16/30	53.33
excess	14	23.33	**2/60**	**3.33**	**12/60**	**20**
			2/14	14.29	12/14	85.71

the most commonly affected (19, or 31.67% of the study population) and those with overweight were the least affected (11.67%). Similar proportions were found among the 37 pre-schoolers with protruding shoulder blades: 20 (33.33%) with normal BMI, and 6 (10%) with overweight. In addition, 23.33% with exaggerated lumbar lordosis were within normal BMI (Table 4).

In 11 (18.33%) children, including 7 girls and 4 boys, no postural abnormality was found. In 9 cases (4 girls and 5 boys) an accumulation of three defects was found simultaneously. However, in one girl and one boy this accumulation involved four coexisting postural defects. In both sexes, the most frequent coexisting defects were flat foot, knee valgus and deepened lumbar lordosis.

Table 4. Proportion of postural dysfunction in relation to population BMI classification criteria – SHS ordinal variable with subset extraction (RP code).

Dysfunction			According to BMI classification					
RP/ code	SHS	subset	deficiency		norm		excess	
			n	%	n	%	n	%
1	asymmetric and/or protracted shoulder positioning (n = 39)		13	21.67	19	31.67	7	11.67
2	protruding shoulder blades (n = 37)		11	18.33	20	33.33	6	10
3	arching of the feet (n = 34)	flat (n = 21)	6	10	9	15	6	10
		lowered (n = 13)	4	6.67	5	8.3	4	6.67
4a	exaggerated lumbar lordosis (n = 30)		5	8.3	14	23.33	11	11.67
4b	positioning of the knees (n = 30)	genu valgum (n = 22)	2	3.33	10	15	10	15
		genu varum (n = 8)	3	5	3	5	2	3.33
5	swollen abdomen (n = 28)		5	8.3	10	15	13	21.67
6a	head protruded forward (n = 16)		4	6.67	8	13.33	4	6.67
6b	formation of thoracic kyphosis (n = 16)	decreased (n = 10)	4	6.67	6	10	0	0
		increased (n = 6)	1	1.67	3	3.33	2	3.33
7	scoliosis (n = 10)		2	3.33	6	10	2	3.33
8	chest shape (n = 5)	barrel (n = 3)	0	0	3	5	0	0
		pectus excavatum (n = 2)	0	0	1	1.67	1	1.67

DISCUSSION

The apparent accumulation of postural defects among pre-schoolers within asymmetric and/or protracted shoulder positioning (65%), as well as protruding shoulder blades (61.67%) should be linked to the predominance of environmental stimuli influencing this condition. The third set in terms of cases, dysfunctions within the arching of the feet (56.67%), may already have more to do with a genetic background.

An increasing proportion of overweight and obese children have been reported in recent years [18, 5]. Among others, it was found that children with musculoskeletal pain had a higher rate of total time spent in front of a screen per day and the longest time spent in front of a screen without a break [1, 19]. These phenomena may be related to increasing postural abnormalities [3]. Thus, it makes sense to recommend that effective intervention be extended to younger generations from the earliest educational stages [19].

A meta-analysis by Chang et al. [20] also indicated a significant increase in body weight and BMI during pandemic-induced isolation among school-aged children and adolescents – also an increased prevalence of obesity and overweight.

As a result of COVID-19 pandemic-induced isolation, children in different parts of the world gained weight, which may be related to increased food intake, physical inactivity, increased time spent in front of a screen or more frequent snacking [21].

In the study group of children from Łomża (Poland), half of both girls and boys were found to meet population norms for BMI, while excessive body weight was found in 23.33% of children, of which 20% were boys.

A comparative analysis of the results of similar studies prior to the COVID-19 pandemic leads to the conclusion that the dynamics of these phenomena have the character of a persistent trend precisely from the earliest periods of ontogeny. However, researchers do not apply uniform criteria for estimating the proportion of cases found. That is, some relate the results to a population sample, while others relate the results to sex (but subsets are not always proportional)

Jankowicz-Szymańska et al. [22] found overweight in 21.1% of girls and 14.5% of boys. Hrycyna and Kołakowski [23] found excessive body weight in 75% of boys and 33% in girls. The differences from our study (children 5-6 years old) may be due to the different age of the children (7-9 years old) from the cited report [23]. The results of the study by Srokowska et al. [24] show that excessive body weight, as identified by the BMI index, accounted for an insignificant proportion of pre-schoolers (out of 95, from a large city in Poland, 4 boys and 2 girls). Bogucka and Głębocka [4] found that the difference between the incidence of postural defects between the sexes of 9-12 year-old children concerned only the positioning of the shoulder blades when body weight was deficient. Similar results were obtained by Wyszyńska et al. [25].

The results of our study provide evidence that postural defects affect children with normal BMI, overweight and underweight alike, and these are not isolated observations [e.g. 26].

An in-depth analysis of various aspects of the issue provides, inter alia, the following observational data. Maciałczyk-Paprocka et al. [27] proved that the prevalence of postural defects is higher among overweight and obese children and adults than among those with normal indices (69.2% of postural defects were found, compared with 78.6% in the obese group). In addition, the researchers found that children with excessive body weight most often included those with valgus knees and flat feet [28]. Among the 7-15 year-old girls studied by Łubkowska et al. [28], 30.8% were characterised by overweight and abnormal spinal alignment.

An important limitation of our study is the lack of knowledge about the physical fitness of preschoolers. This observation also applies to almost all research results available in the literature bases. Not only in a cognitive sense is the issue of physical fitness important for children, but also for adults who have been found to accumulate multiple postural defects. This approach puts into perspective the necessity of reaching for methods based on a complementary approach.

CONCLUSIONS

There is no basis for concluding that COVID-19 pandemic significantly increased postural defects among 5-6 year-old pre-schoolers. The extended analysis of the phenomenon of postural defects and associated with BMI indices shows the prospect of further exploration based on a complementary approach. We consider it necessary to enrich this research with elements of estimating the physical fitness of the subjects along with their daily and weekly physical activity and diet quality. In our opinion, such knowledge should form the basis for the development of individualised intervention programmes.

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