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Article

Assessment of the occurrence of postural abnormalities in children aged 10-12 practicing various sports disciplines

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Abstract: Background: The increase in the prevalence of children with poor posture might be a result of decreased physical activity due to a sedentary lifestyle. Observing body posture is a crucial component of a physical examination. The examination can be performed objectively, for instance, with the aid of specific instruments, or subjectively, through visual inspection of the alignment of individual body parts in relation to one another. **Objectives**: The aim of our

study was to assess the occurrence of postural abnormalities in children aged 10-12 who are physically active and practice various types of sports. **Methods:** The study group comprised 47 children aged 10–12 who were physically active and engaged in various sports activities. Participants have been visually examined based on a postural deficit chart derived from Kasperczyk's criteria. **Results:** Our research showed that volleyball had the highest percentage of postural abnormalities, accounting for 33% of all postural irregularities in this group, while the lowest percentage was observed in children who practiced swimming, at 7%. **Conclusion:** Physical activity may have an impact on the occurrence of postural defects in early school children. Further research is needed to expand our findings to include the outcomes of objective posture assessment methods.

Keywords: body posture; postural abnormalities; children; sports; physical activity

1. Introduction

Body posture, which is defined as the way the human body is spatially positioned, is an individual feature of each person, as well as one of the determinants of our health [1, 2, 3, 4] It is a dynamic state and undergoes many changes depending on age, affecting physical and intellectual ability, providing cognitive and social development in many areas of our lives [1,2]. Good posture is a state of equilibrium of each part of the body in relation to each other and the long axis of the body. It is maintained with minimal tension of the muscular system and involvement of the nervous system. A postural defect is considered as any irregularities and deviations from correct body posture. Postural abnormalities may be related to muscle imbalances that cause diversions at the positional or structural levels [3, 4]. The literature analysis showed a noticeable and significant increasing tendency in the number of abnormalities in body posture in children from the earliest age [5, 6]. Single posture defects, such as asymmetrical positioning of the shoulders, shoulder blades, pelvis, or valgus foot, result in the development of compensatory mechanisms at a later age, thus leading to posture defects, deformations of the musculoskeletal system and, consequently, limited mobility [7, 8, 9].

According to research conducted by Health Behavior in School-aged Children (HBSC) in the years 1999–2010 on European children, the number of factors contributing to the development of postural defects is currently increasing [10, 11]. The most noticeable

phenomenon is children's limited physical activity, sedentary lifestyle, improper eating habits and ways of spending their free time, leading to an early increase in the percentage of overweight and obesity [12, 13, 14, 15]. Factors that may directly influence its occurrence, such as adopting an incorrect position during school classes or rest, having an inappropriately adjusted study space, or carrying overly heavy backpacks to school, are also important when the symptoms associated with poor posture intensify [19,20,21].

The period when children start attending school and reach puberty are crucial stages for upholding correct bodily alignment [19]. Changes occurring in the learning approach of children aged 10–12, like more subjects and homework, lead to more time spent at school and studying at home. These differences are causing a shift in children's daily physical activities, as they transition from having plenty of freedom to move to remaining seated for prolonged periods at school, often in conditions that are not entirely well-suited, potentially leading to or exacerbating changes in their body alignment [20, 21].

Observing body posture is a crucial component of a physical examination. The examination can be performed objectively, e.g., with the aid of specific instruments [20, 22, 23], or subjectively, through visual inspection of the alignment of individual body parts in relation to one another, for instance, by incorporating Kasperczyk's point method [24, 25]. The subjective nature of the assessment is prone to measurement errors; and therefore, its outcome relies on the evaluator's experience. Nevertheless, the advantage of visual assessment is the simplicity of the examination, which can be conducted in a short time without the need to use additional equipment.

In many studies we have found a comparison of two groups - children who practice and those who do not practice a specific sport [26, 27, 28, 29, 30, 31]. However, our study takes into account the occurrence of postural abnormalities among children practicing various sports. Therefore, the aim of our study was to assess the occurrence of postural abnormalities in children practicing various sports disciplines.

In our research we considered two hypotheses:

1. The occurrence of specific postural abnormalities is related to on the sports discipline practiced.
2. Asymmetric sports may predispose to a greater number of postural abnormalities.

2. Methods

We conducted our research in February and March 2017 at Primary School No. 8 in Świecie, a small town in central Poland. The research protocol was approved by the Bioethics Committee of the Ludwik Rydygier Collegium Medicum in Bydgoszcz, Nicolaus Copernicus University in Toruń (no. KB/741/2016, date of approval: December 13, 2016).

2.1. Patricipants

Children were enrolled in the study through an interview questionnaire that collected basic personal details such as their name, date of birth, and place of residence, as well as information on their physical activity habits during school hours and leisure time, including any additional sports activities.

Study inclusion criteria were as follows: (1) healthy children aged 10 to 12; (2) consent of the children's parents or guardians to perform the test; (3) qualification to the group of physically active children—participation in sports activities organized by sports clubs, school or individually, at least twice a week (duration on each session 1.5 hour), for a minimum of 1 year. Study exclusion criteria were as follows: (1) presence of abnormalities in body posture. The study involved 47 children who participated in physical education classes on the days that the study was conducted. Among the 47 children examined, 59.58% (28 individuals) were girls while 40.42% (19 individuals) were boys. The study population comprised of 34.04% children aged 10, 36.17% children aged 11, and 29.79% children aged 12. The detailed characteristics of the study population are presented in Table 1.

Table 1. Characteristics of the study group, including age and gender.

	Age 10		**Age 11**		**Age 12**		**Total**	
	N	%	N	%	N	%	N	%
♀	10	21.28%	8	17.02%	10	21.28%	**28**	59.58%
♂	6	12.76%	9	19.15%	4	8.51%	**19**	40.42%
Total	43	34.04%	54	36.17%	34	29.79%	**47**	100%

N – number of children.

2.2. Sample size estimation

We calculated the sample size using the minimum sample size estimation formula (Nmin) [32]:

$$N_{min} = \frac{P(1-P)}{\frac{e^2}{z^2} + \frac{P(1-P)}{N}}$$

The general population (N = 47) consisted of children aged 10–12 attending sport classes at Primary School No. 8 in Świecie. Based on the assumptions made (sample proportion = 70 % (P = 0.7), confidence level = 95 % (z = 1.96), and margin of error = 5% (e = 0.05), it was established that a minimum of 41 children should participate in the study.

2.3. Body posture assessment

To the assessment of body posture we used visual analysis of the alignment of particular body parts, by incorporating Kasperczyk's point method. The study consisted of assessing the following elements in given areas: (1) in the sagittal plane: assessment of the position of the head, shoulders, shoulder blades, abdomen and spine position; (2) in the frontal plane (front position): assessment of the position of the head, shoulders, anterior superior iliac spines, knees, feet; (3) in the frontal plane (backward position): assessment of the position of the shoulders, scapulae, posterior superior iliac spines, and spinous processes. Each element of the examination was scored on a scale from 1 to 2, with 0 points – correct alignment of the evaluated part; 1 point – slight deviations from the correct alignment; 2 points – significant deviations from the correct alignment. Upon summing up the points from the assessment, it was observed that a lower score signified fewer deviations from the standard alignment of body parts in children. Each examination was performed by the same researcher with 5 years of experience in assessing body posture (D.B.) at the same time of day (9–10 a.m.) before physical education classes. Each assessed child was asked to stand barefoot in a relaxed, unforced body position. In each case, the examination was carried out in daylight, against the same background that did not disturb the observation of the body (white wall). Before starting the assessment, the researcher marked landmark bone points on the body to facilitate posture assessment using a marker pen.

3. Results

Table 2 shows data on children divided into groups of individuals practicing various sports expressed as the numerical count and percentages.

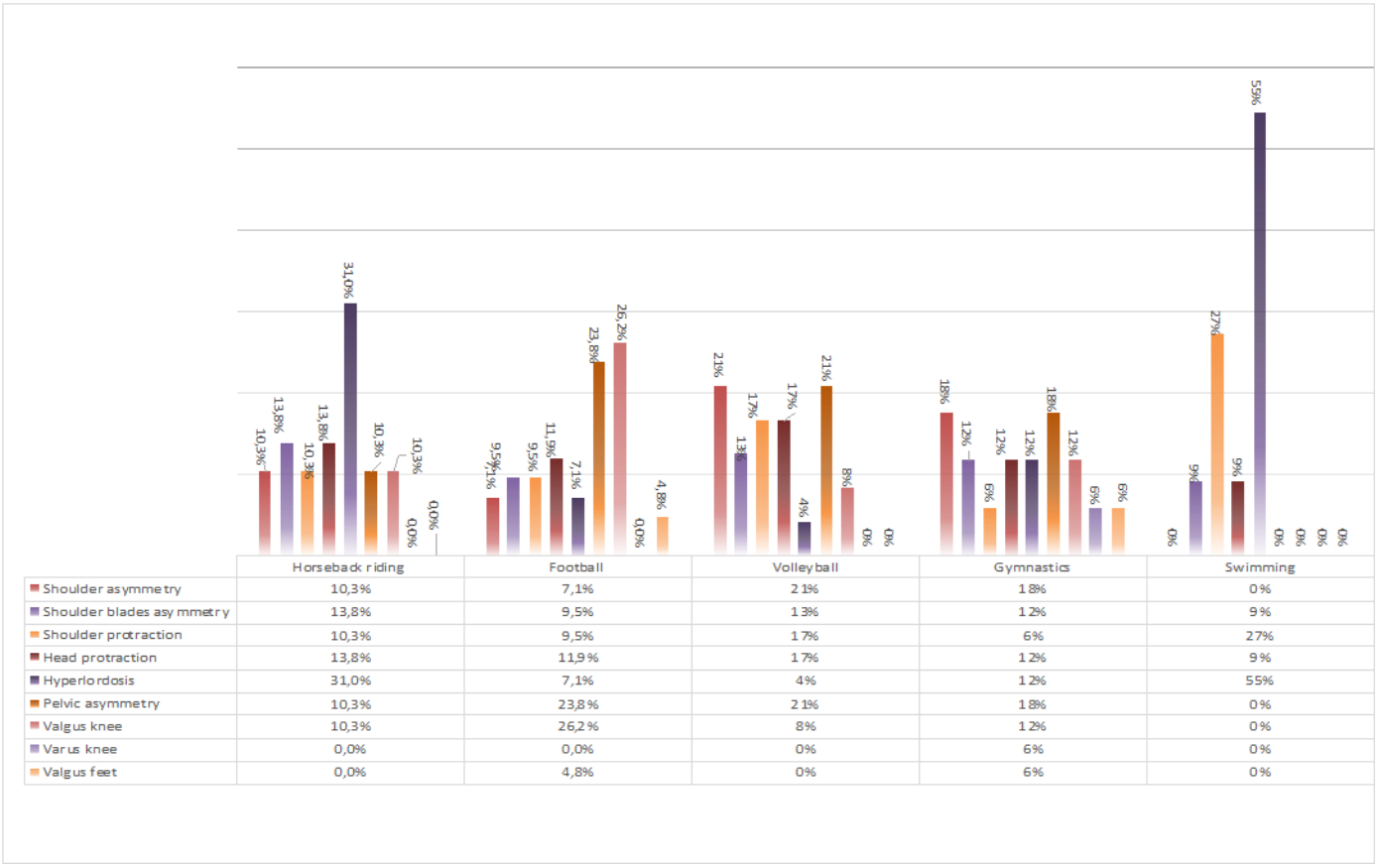
Table 2. Population of children practicing sports.

Sports	**Number of respondents**	**Percentage**
Football	13	27.7%
Volleyball	11	23.4%
Swimming	10	21.3%
Horseback riding	9	19.1%
Gymnastics	4	8.5%
TOTAL	**47**	**100%**

Table 3. Body posture abnormalities in the group of children actively practicing sports.

Group of children / Body posture abnormalities	**Actively practicing**	
Shoulder blade asymmetry	33	15.6%
Winged scapula	31	14.6%
Shoulder protraction	35	16.5%
Head protraction	39	18.4%
Hyperlordosis	20	9.4%
Pelvic asymmetry	18	8.5%
Varus knee	7	3.3%
Valgus knee	16	7.5%
Valgus foot	13	6.1%
Total	**212**	100%

The results in Table 3 demonstrate the occurrence of postural abnormalities in the group of children who actively practice sport. In the group of children practicing sports, the most common abnormality was head protraction—18.4%, while the least common was varus knee—3.3%.

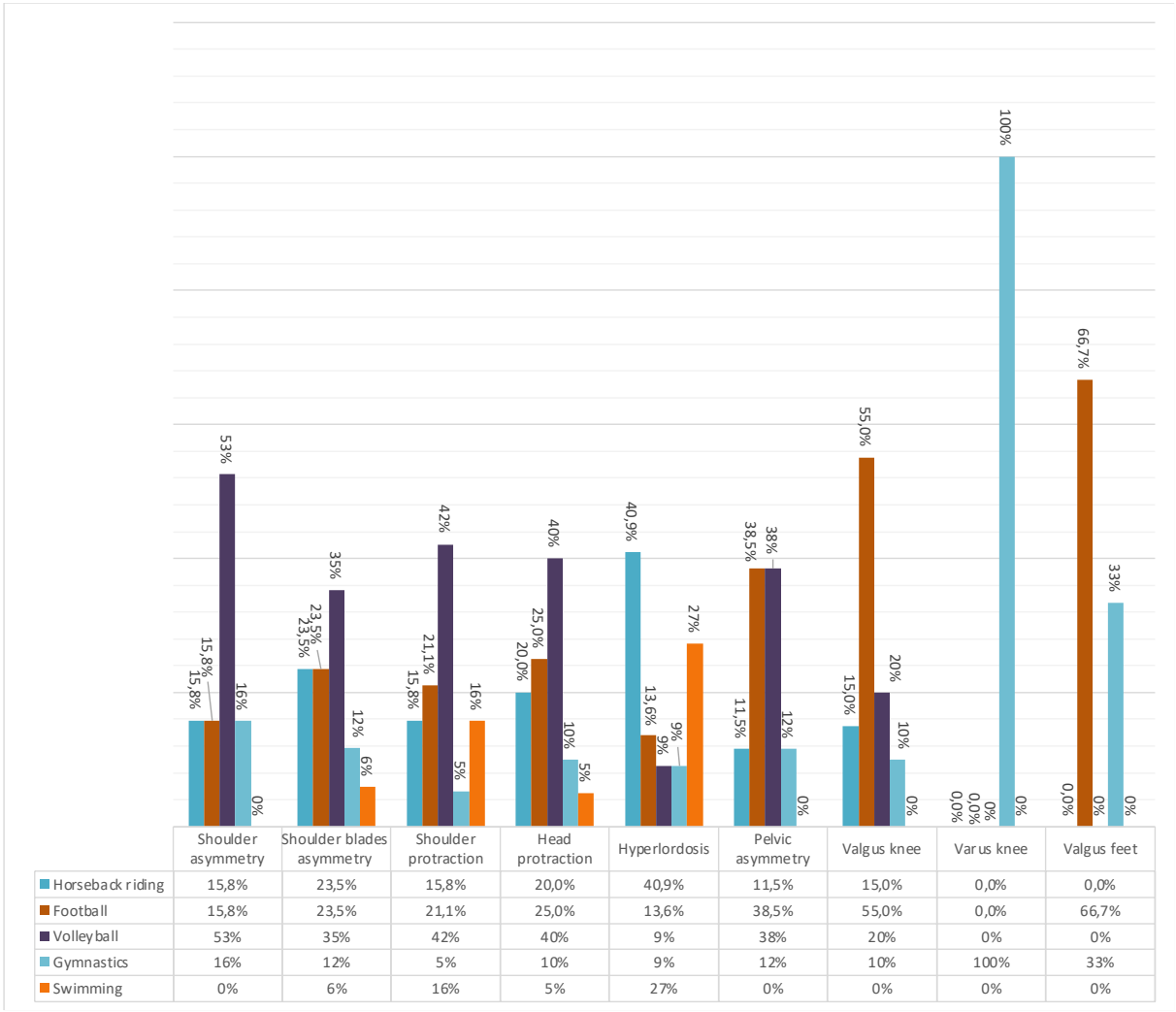


	Horseback riding	Football	Volleyball	Gymnastics	Swimming
Shoulder asymmetry	10,3%	7,1%	21%	18%	0%
Shoulder blades asymmetry	13,8%	9,5%	13%	12%	9%
Shoulder protraction	10,3%	9,5%	17%	6%	27%
Head protraction	13,8%	11,9%	17%	12%	9%
Hyperlordosis	31,0%	7,1%	4%	12%	55%
Pelvic asymmetry	10,3%	23,8%	21%	18%	0%
Valgus knee	10,3%	26,2%	8%	12%	0%
Varus knee	0,0%	0,0%	0%	6%	0%
Valgus feet	0,0%	4,8%	0%	6%	0%

Fig. 1. Occurrence of postural abnormalities among children practicing various sports.

Fig. 1 presents the prevalence of body posture abnormalities based on the specific type of sport practiced. The research revealed that hyperlordosis was found to be the most common postural abnormality among children who engage in horseback riding, with a prevalence of 31%, whereas asymmetry and protraction in the shoulders, pelvic asymmetry, and valgus knee showed more evenly distributed percentages, each at 10.3%. Valgus knee was most prevalent in children practicing football, with a rate of 26.2%, followed by pelvic asymmetry at 23.8%, while valgus foot was least prevalent, at 4.8%, and varus knee was absent in this group. In the group of children who play volleyball, the most noticeable postural irregularities were found in the pelvis and shoulder, with a prevalence of 21% of asymmetry in each case, whereas no common issues with lower limbs, such as varus knee and valgus foot, were observed (0%).

Among the children practicing gymnastics, 18% demonstrated shoulder and pelvic asymmetry, while shoulder protraction, varus knee, or valgus foot were evident in only 6% of the study participants. However, hyperlordosis was the most prevalent abnormality identified in children practicing swimming comprising 55% of cases, yet no deviations were noted in the pelvis or lower limbs.



	Shoulder asymmetry	Shoulder blades asymmetry	Shoulder protraction	Head protraction	Hyperlordosis	Pelvic asymmetry	Valgus knee	Varus knee	Valgus feet
Horseback riding	15,8%	23,5%	15,8%	20,0%	40,9%	11,5%	15,0%	0,0%	0,0%
Football	15,8%	23,5%	21,1%	25,0%	13,6%	38,5%	55,0%	0,0%	66,7%
Volleyball	53%	35%	42%	40%	9%	38%	20%	0%	0%
Gymnastics	16%	12%	5%	10%	9%	12%	10%	100%	33%
Swimming	0%	6%	16%	5%	27%	0%	0%	0%	0%

Figure 2. The impact of various sports on the development of postural abnormalities

Fig 2. The impact of various sports on the development of postural abnormalities

Fig. 2 indicates that children playing volleyball demonstrate the highest rate of postural abnormalities in the trunk, whereas those participating in football activities display the highest percentage of issues in the lower limbs. The lowest percentage of postural abnormalities was recorded in children who practice swimming.

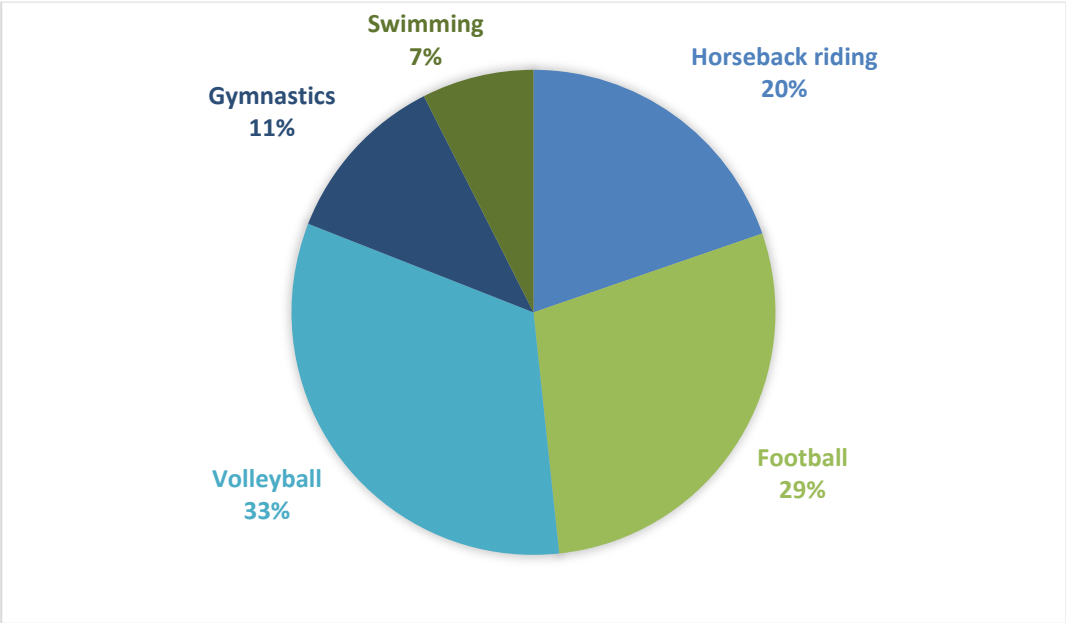


Fig. 3. Percentage of sports activities associated with postural defects in a group of physically active children.

Data presented in Figure 3 indicates that among children engaged in sports, volleyball players demonstrate the highest percentage of postural defects accounting for 33% of cases, while swimmers have the lowest occurrence at 7%.

4. Discussion

The aim of our study was to assess the prevalence of postural abnormalities in a group of physically active children practicing various types of sports. Physical activity clearly impacts body posture, reducing the occurrence of postural defects, as highlighted in numerous papers [26, 27, 28, 29, 31, 33, 34]. Moderate exercises contribute to the proper physical, mental, and social development in children while reduced physical activity leads to abnormalities of the musculoskeletal system. In their studies, McMaster et al. showed that lack of physical activity is a predisposing factor to the onset of spinal deformities and other conditions [33]. Nonetheless, it is crucial to note the disparity between a physically active study group and a control group that is physically inactive, as high-lighted by numerous researchers.

In accordance with our first hypothesis, we confirmed that he occurrence of specific postural abnormalities is related to the sports discipline practiced. Our research findings highlighted the relationship between postural defects and children's preferred activities, thus resulting in a formation of a study group comprising of children who are actively dedicated to a specific sport. Many researchers in their studies compared one sport discipline to a control

group, usually inactive children, which makes it difficult to accurate compare other authors' studies to ours.

Due to the assumptions of the second hypothesis, we confirmed the occurrence of a higher percentage of postural abnormalities in the group of children practicing asymmetric sports. Among children who engaged actively in sports, those practicing volleyball demonstrated the highest percentage of postural defects, accounting for 33% of the total defects identified in the study. In this group, asymmetry of the shoulder girdle and pelvis was observed as the most common body posture defect, along with excessive protraction of the head and shoulders. Research conducted by Hadzik and Grabara showed similar results, indicating a tendency for volleyball players to have excessive thoracic kyphosis, affecting up to 48% of young girls practicing this sport [30]. Furthermore, studies have found that the body posture of young volleyball players changes over two years of regular training compared to non-training individuals. These studies indicate that volleyball training can lead to an asymmetrical effect on the position of the shoulder and pelvic girdle.

Volleyball is classified as an asymmetric sport, where one half of the player's body tends to dominate. An attack or serve is a demanding move that demands substantial physical power and muscle strength. Analysis of our study results showed that the highest percentage of shoulder asymmetry was observed in children who play volleyball—58%, while pelvic asymmetry was observed in 42% of girls. Similar observations are present in Grabara's research [28], where the incidence of a lowered shoulder and scapula was observed in 45% of volleyball players. The results of our study align with those of other researchers who hypothesized that volleyball training might lead to an asymmetrical influence on the shoulder girdle, shoulder blades, pelvic position, and spinal curvature arising from specific movement patterns [34, 35, 36, 37].

Another group in which a high percentage of irregularities was observed by us were young soccer players. We noticed that 23.8% of children in this group had pelvic asymmetry and 26.3% had valgus knee. Pietraszewska et al. emphasized in their research that the occurrence of pelvic asymmetry along with scoliotic posture was also observed in 29.3% of boys training football [38]. Even though in the research conducted by Grabara no significant differences were observed between the occurrence of pelvic asymmetry in the study and control groups, there is a high percentage of boys with increased lumbar lordosis [27]. An increase in lumbar lordosis was also reported in studies conducted by Asadi et al. who investigated postural abnormalities among adult soccer players com-pared to amateur players. The researchers observed a

significant difference between the control group and the research group. This was seen in the increased occurrence of lordosis and pelvic asymmetry among football players [26]. In our own research, we noticed a correlation between football training and pelvic asymmetry. However, we did not find a significant relation between the occurrence of hyperlordosis and this sport. Compared to other physical activities, excessive lordosis occurred rarely in boys practicing football, accounting for only 7.1% of young athletes.

The lowest percentage of postural abnormalities (7%) we've observed in children practicing swimming. Our research findings reveal that the predominant postural defect observed in this group of individuals was increased lumbar lordosis, with a frequency of 55% among children practicing swimming. Maćkowiak and Wiernicka's study on 67 adolescent girls aged 13–18, of which 33 were swimmers and 34 were not physically active, revealed a correlation indicating that girls practicing swimming had 50% fewer postural abnormalities compared to the non-active control group [31].

The findings indicate that the body alignment, both in the sagittal and frontal planes, of the pupils in the research group closely resembles the correct posture, suggesting that swimming may lead to fewer postural abnormalities. Nevertheless, numerous scholars suggest that swimming training negatively affects the development of spinal curvatures in the sagittal plane, as confirmed in the study by Fajdasz et al. Their findings demonstrated that young swimmers with a rounded back exhibited better body posture com-pared to the control group [39]. Zaina et al. also observed comparable outcomes, demonstrating a correlation between swimming and an increased risk of trunk asymmetry, hyperkyphosis, and hyperlordosis [19]. Furthermore, Huang Y. et al. observed a higher likelihood of excessive thoracic kyphosis in swimmers compared to the control group [40].

Numerous studies indicate that posture abnormalities are prevalent among young children starting from the early school years and sometimes even during preschool [2, 5, 9, 23, 25,]. Developed postural defects may be attributed to a variety of factors that the authors of this study took into consideration. Improper eating habits, environmental aspects such as the family household and school, participation in extracurricular activities, level and nature of physical activities, and primarily, their restriction, and in severe in-stances, complete lack of thereof, are key contributors to this phenomenon [1, 9, 10, 15, 23].

Body posture is a subject frequently explored by researchers. However, the evaluation criteria for assessing body posture are not always consistent. Such lack of uniformity in assessment criteria can pose challenges when comparing study findings. Numerous scholars

use subjective research methodologies for measurement, such as visual assessment of individual's posture [2, 20, 22, 21, 26, 36], as is the case of our study. The result of the subjective method of examining body posture may cause potential bias and error due to the knowledge and experience of the evaluator. However, we decided to use this method of examination because it can be performed in a short time without having access to specialistic equipment. Therefore, the methodology we used can be repeated as part of screening studies on large groups of children, and easily replicated by other research teams that do not have access to objective research equipment. Besides visual assessment, several researchers use a spinal mouse [26], a goniometer [3], as well as a scoliometer and a plumb line [20, 22]. Nonetheless, current research on body posture relies on computerized methods for body posture assessment, for instance, the Moire technique [15, 16, 19, 27, 28, 29, 30, 37], the SpineScanSH-115 software [40], posturometer-S computer analysis [31, 38], as well as Zebris software [8]. When examining body posture in children, it is crucial to exclude certain factors, such as the time of day or the level of physical activity before the assessment, that could impact the results. The accurate assessment of body posture also hinges on the knowledge and skill of the individual performing the assessment. In the process of reviewing the literature, limited data was found on factors that had indirect influence on the research subjects, such as the examiner's qualifications, time of day, place, and the fact whether they remained consistent for all participants [20, 22, 10, 11, 14, 15, 27, 28, 29, 31, 37, 38, 40]. Several research studies have taken into account the significance of the examination's timing [27] and included information about the examiner [36]. These observations suggest that there is currently a lack of established guidelines for conducting body posture assessments in children, which would take into account various factors that impact posture quality both directly and indirectly.

According to the results of our research, the highest percentage of postural abnormalities occurs in children practicing asymmetrical sports - volleyball, football. Therefore, a practical implication for this type of sports will be to add elements such as general development training and resistance training considering symmetrical loading. Another important aspect will be to encourage children practicing this type of sports to add some trainings of other more symmetrical sports disciplines for ex. swimming.

Further research is needed to extend our findings. In subsequent studies, more objective methods of posture assessment based on standardized research protocols should be used. Each sport affects motor development, or posture differently according to different settings (water), training loads (arms or legs) or content etc. (e.g. horse riding is stated to help children with

cerebral palsy in developing postural control), therefore it will be worth in next research taking into account the division of sports disciplines, e.g. into group sports and individual sports.

5. Study limitations

We are aware of the limitations of our study. The study used only a subjective method of examining body posture through visual observation, whose accuracy reliability and validity have not yet been confirmed - which carries a significant risk of error. Furthermore, the study group was not homogeneous in terms of gender and sample size was small. An additional limitation is the small number of sports disciplines in the studied group of children.

6. Conclusions

Engagement in physical activities might affect the prevalence of postural defects in early elementary school-aged children. Volleyball players had the highest percentage of postural abnormalities compared to children in other sports. The lowest percentage of postural abnormalities (7%) was observed among children practicing swimming. In light of study limitations, it is crucial to exercise caution when drawing conclusions from the study and avoid making overarching statements about the relation between physical activity and postural abnormalities in early elementary school-aged children.

Further research is needed to expand our findings to include the outcomes of objective posture assessment methods based on standardized research protocols.

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Informed consent statement: All participants provided written informed consent for the study.

Data availability statement: Data sets generated or analyzed during the current study are available from the corresponding author upon reasonable request.
Conflicts of Interest: The authors report no conflict of interest.

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