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OFICJALNE PISMO POLSKIEGO TOWARZYSTWA FIZJOTERAPII

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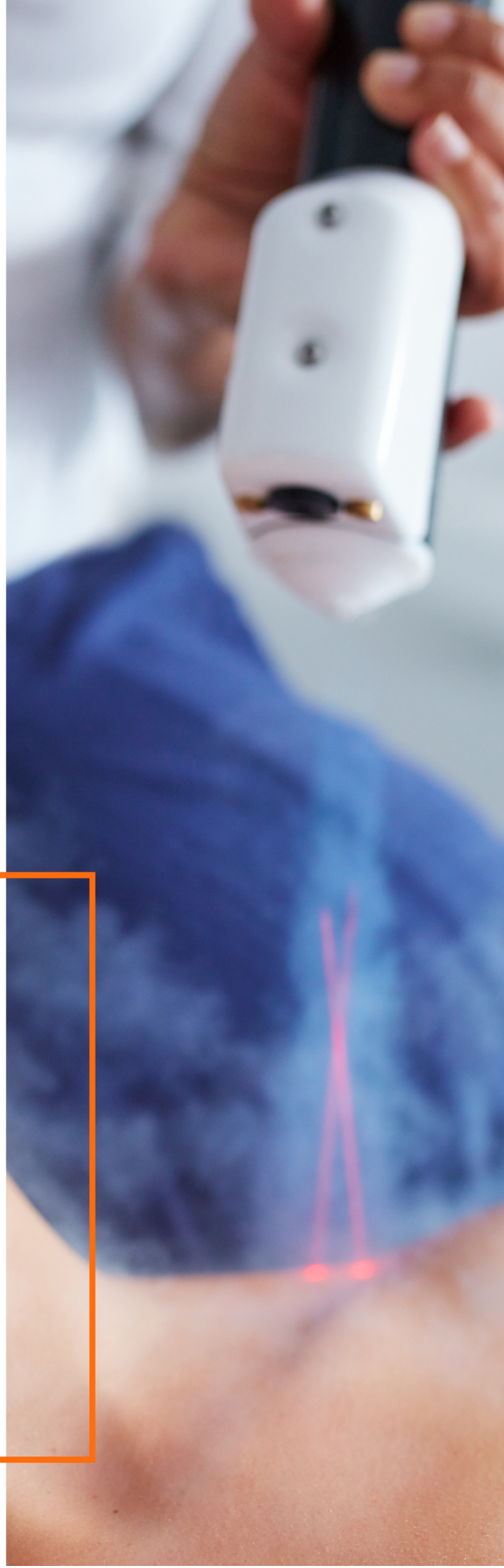

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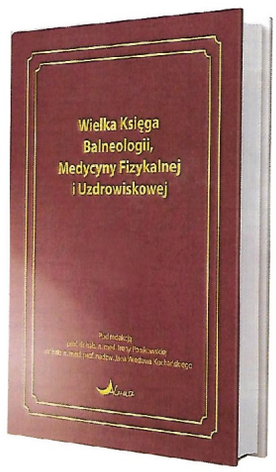

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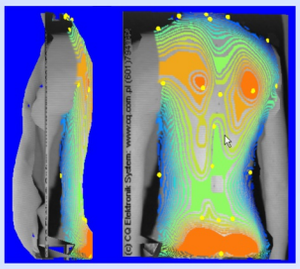

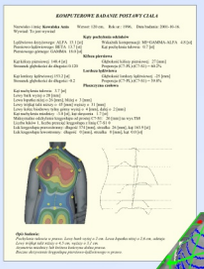

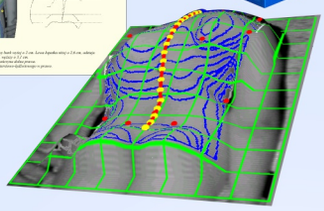

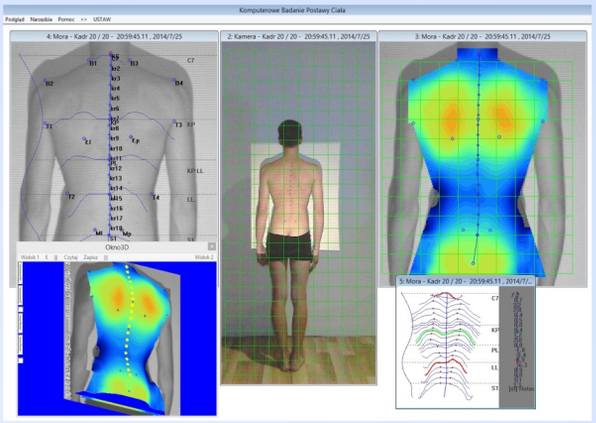

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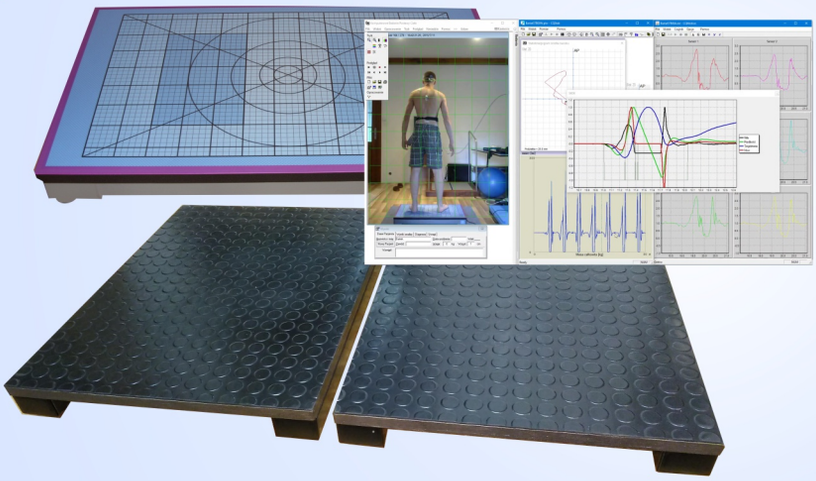

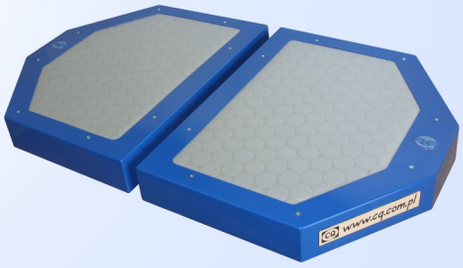

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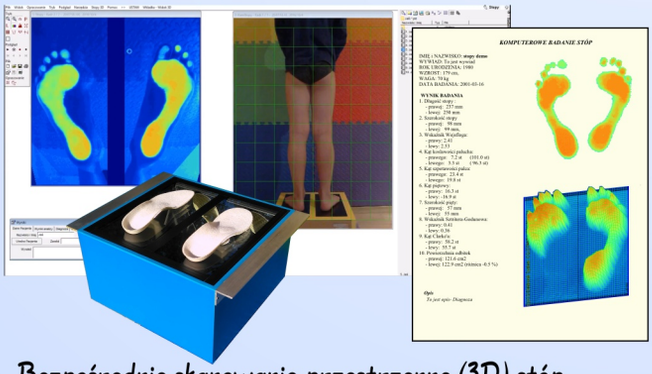

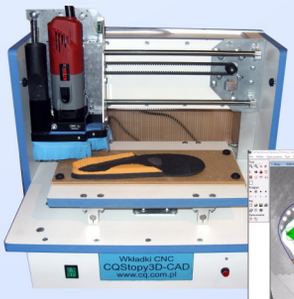

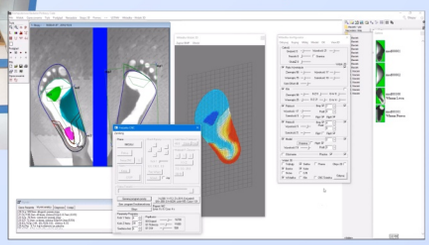

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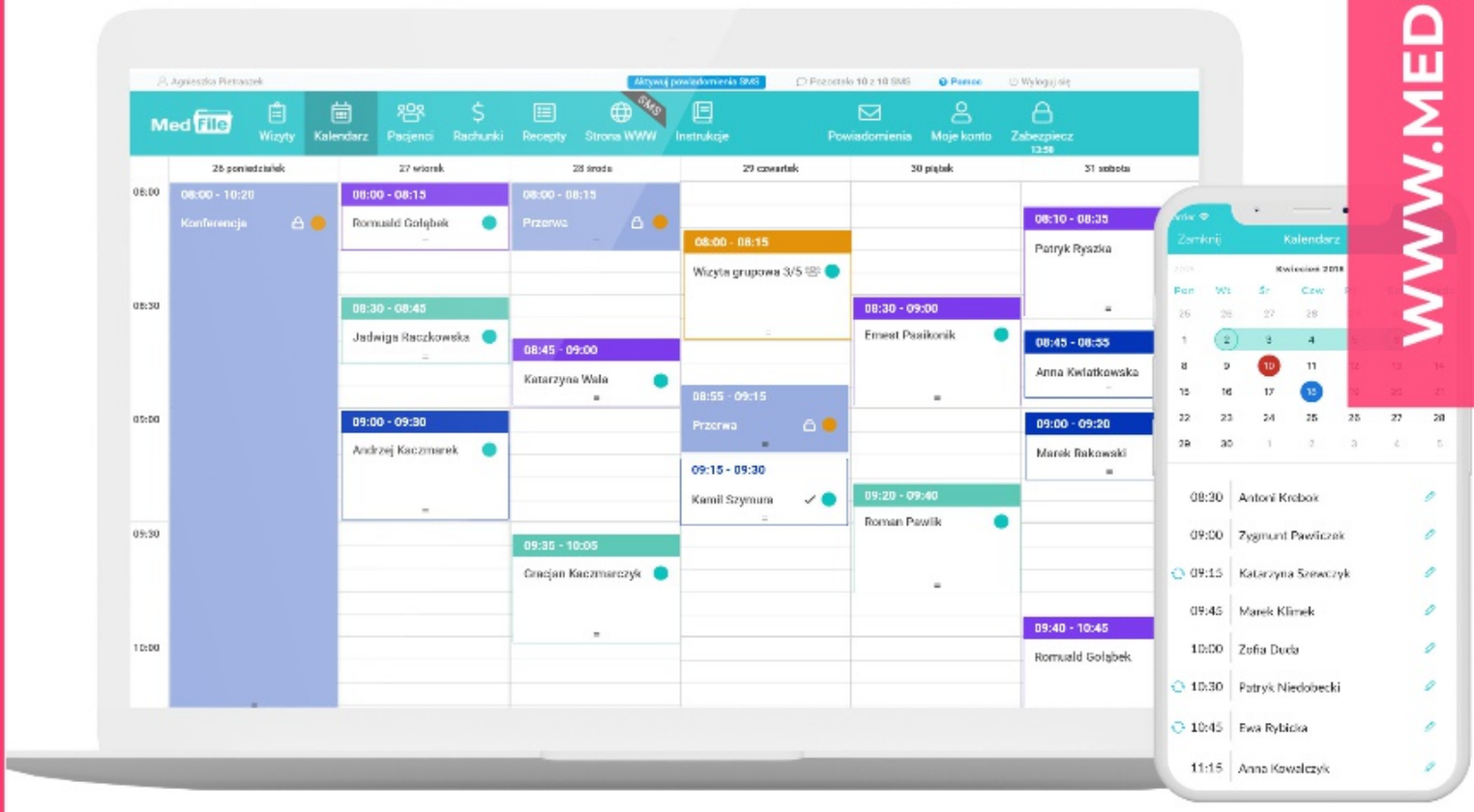

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Charakterystyka lateralizacji u dzieci w wieku 5-7 lat

Characteristics of lateralization in children aged 5-7 years

5-7 岁儿童的偏侧化特性

Sylwia Potępa[1(A,B,D,E)], Aleksandra Czaplińska[2(B,C)], Alicja Salwach[3(C,D)], Lawia Szkoda[1(C,D)], Andrzej Szopa[1(E,F)], Małgorzata Domagalska-Szopa[2(E,F)]

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[2]Wydział Nauk o Zdrowiu w Katowicach, Śląski Uniwersytet Medyczny w Katowicach, Zakład Rehabilitacji Leczniczej / School of Health Sciences in Katowice, Medical University of Silesia in Katowice, Chair of Rehabilitation, Poland
[3]Wydział Rehabilitacji Ruchowej, Akademia Wychowania Fizycznego im. Bronisława w Krakowie / Faculty of Rehabilitation, University of Physical Education in Kraków, Poland

Streszczenie
Lateralizacja nazywana również „asymetrią funkcjonalną" jest nieodzowną częścią prawidłowego rozwoju psychofizycznego każdego człowieka, która zależy od wyspecjalizowania półkul mózgowych. Lateralizacja charakteryzuje się większą sprawnością jednej strony ciała od drugiej oraz różnicami w rejestracji bodźców zmysłowych przez mózg. Lateralizacja jest istotnym czynnikiem, który rozwija się wraz ze sposobem w jaki nasze ciało orientuje się w przestrzeni, wykonuje zadania motoryczne, pomaga w kształtowaniu somatognozji oraz ostatecznego kształtu ciała.
Celem niniejszej pracy było ustalenie oraz obserwacja kształtowania się przebiegu lateralizacji u dzieci w wieku przedszkolnym i wczesnoszkolnym.
Materiał i metody. Grupę badaną stanowiło 110 dzieci w tym 55 dziewczynek i 55 chłopców w wieku 5-7 lat ze szkół podstawowych oraz przedszkoli z województwa śląskiego. Podczas badania zostały przeprowadzone próby diagnostyczne tzw. obserwacje swobodnego wyboru oka, ucha, kończyny górnej oraz dolnej.
Wyniki. Wykazano, że wraz z wiekiem wzrasta liczba dzieci o ustalonym profilu dominacji. U 35% dzieci zaobserwowano zaburzenia w postaci lateralizacji skrzyżowanej, najczęściej ten model występował w grupie dzieci 5-letnich.
Wnioski. Z otrzymanych danych wynika, iż dzieci w wieku 5-7 lat nie mają ukończonego procesu lateralizacji.

Słowa kluczowe:
lateralizacja, asymetria funkcjonalna, dominacja stronna

Abstract
Autism spectrum disorder (ASD) represents an extensive class of symptoms manifested as deficiencies in such fields as communication, social development and stereotypical behavioural patterns. Autism symptoms appear in social interactions issues, mood disorders, somatosensory disorders, concentration problems. The conversion disorders are frequently diagnosed in autistic children. Maintaining the standing balance is an immensely important skill in the child's development, which consists in controlling the centre of gravity over the support plane. Appropriate balance is necessary for successful performance of numerous daily actions. Retarded development of balance impedes the future motor development and affects the opportunity of the children's involvement in interactions with peers.
The purpose of this paper was an impartial evaluation of balance skills in children with autism spectrum disorder.
Material and methods. 30 children 5-7 year-old with ASD, including 22 boys and 8 girls. Methods: The Scoring Form for Fullerton Advanced Balance (FAB) Scale test was used for evaluation of the balance.
Results. The lowest results were obtained in the tandem walk and stand on one leg test. The test results varied in specific age groups, however, the differences were not significant. Substantial differences were displayed in tandem gait test for specific age groups.
Conclusions. In children with ASD disorders in balance skills occur.

Key words:
lateralization, functional asymmetry, side dominance

摘要
偏侧化也被称为"功能不对称"，是每个人心理物理正确发展中必要的一部分，取决于大脑半球的专业化。偏侧化的特性在于身体一侧的效能高过于另一侧及大脑对感觉刺激记录的差异。偏侧化为一重要因素，随我们身体在空间中定向的方式发展，执行动作任务并协助形成躯体感觉及身体的最终形态。
该研究的目的在确定并观察学龄前及学龄前期儿童偏侧化形成的过程。
材料及方法。试验组由 55 名女孩及 55 名男孩在内共 110 名年龄在 5-7 岁间的儿童组成，他们来自西里西亚省的小学及幼儿园。试验期间进行诊断测试，即随意选择观察眼、耳、上肢和下肢等。
结果。儿童的侧面支配优势确定随年龄而增加，35%的儿童有交叉性偏侧化的失调现象，这种模式最常出现在 5 岁年龄组的儿童中。
结论。根据所获得的数据显示，5-7 岁的儿童偏侧化过程未完成。

关键词：
偏侧化、功能不对称、单侧支配

Introduction

The term of lateralization is derived from the latin language (*lateralis* = side), it is also called bias or asymmetry of the right and left side of our body. It is characteristed by higher level of motor efficiency of one side of the body in comparison to the other and differences in perception of sensory stimuli by the brain [1]. Body laterality is a form of asymmetry. That means a pernament or temporary disturbance of the state of equilibrium or compatibility between different parts of the body. The asymmetry can be divided into: structural/morfological asymmetry (concerns organs, mass of left and right side of the body, lengths and circumferences of limbs, position of even parts of the body); functional asymmetry (concerns perception, speech, smotions, prefered side of the body); dynamic asymmetry (quantitative differences e.g. inmuscle strength, ranges of movement, distance of throw); sensory asymmetry (size and differences in sense organs sensitivity); mental asymmetry (uneven location of mental processes organization centres in both hemispheres of the brain) [2].

It is not only the matter of upper and lower limb domination or sensory preference of ear, eye. It is also an important factor which developes along with orientation of the body in space, executes motor tasks, helps to shape somatognozy and the final body shape. This is an important feature of our bodily experience and it depends on hereditary, socio-cultural and functional factors on different stages of each persons development. Asymmetry causes visible disproportions in the body structure: some brain structures occur only in one side of the skull; the dominant side of the body has usually greater mass than non-dominant side; the dominant upper limb is approximately 1 cm longer than non-dominant limb and has greater mass; the dominant lower limb is approximately 1.0-1.3 cm longer

Morfological and functional asymmetry is visible within preschool and early school children. However at this age the asymmetry in the body structure is physiological [3]. The level of motor activities lateralization among children can be determined by means on an interview, observation and specially selected diagnostic tests. The diagnostic process makes it possible to identify group of children in need of special support and to assess the child's level of motor development.

If it is possible to clearly establish the domination of the organ or the sense we call it a correct lateralization – determined lateralization. Heterogenous lateralization occures when there is no domination of motor and sensory organs or when preference of motor and sensory organs appears on opposite sides of the body. Lateralization can be divided into:

• Homogeneous lateralization: right-side lateralization – the dominance of the right upper limb, eye, ear, lower limb indicates the dominance of the lefit cerebral hemisphere; left-side lateralization – the dominance of the left upper limb, eye, ear, lower limb indicates the dominance of the right cerebral hemisphere.

• Heterogenous lateralization: crossed lateralization – functional superiority of the locomotor system and sense of both sides of the body; undetermined lateralization – no side dominance, no functional superiority of one of the cerebral

hemisphere. In case of undetermined lateralization we can talk about two-handedness, two-eyedness, two-footedness [4].
In the society the right-handedness is prevailing. In the past, left-handed people were classified in the lower social category and left-handedness was treated as disability or a handicap [5]. Nowadays left-handedness is competly accepted. If the child performs the vast majority of the activities with the left hand, it should not be included to be right-handed. Such behaviour will not change their brain preferences.
It should be noted that lateralization does not only concern limbs or sensor organs but also includes the cerebral hemispheres – called brain lateralization. If one of the hemispheres is more capable of registering and processing stimuli in a particular way, it is associated with its dominance in a given activity [6]. It is believed that lateralization of the brain is justified by the evolution. Having one hemisphere that takes control of the processes reduces the chace of both hemispheres competing for control over response. It also allows a simultaneous operation of various phenomena such as language or attention [7].

The aim of study

The objective of this study was to recognize the course and distribution of lateralization in preschool and early school aged children from selected kindergartens and schools.

Material and methods

The study group consisted of 110 children including 55 girls (50%) ald 55 boys (50%) aged 5-7 years, i.e. children who will become 5 years old but under 8, during a year when the study was performed. The mean age of the studied group was 5.9 years ± 9 months and the mediane 6 years. Girls were aged 6 years ± 9 months and boys were aged 5.8 years ± 1 year. There was no statistically significant dependence (χ^2) between sex and age in the study group ($p = 0.53958$).
Diagnostic tests were used to evaluate the lateralization of the body i.e. observation of the free choice of eye, ear, upper limb, lower limb during motor activity. The children were examined individually and each tasks was precided by a verbal instruction. The entire examination took place in classrooms designated by the head of the institution. During all the studies the same set of items was used to assess the direction of lateralization. This set included: a telescope, a ball, a phone, a watch with hands, a large shell, a wooden beehive and bees. Each meeting with a child was conducted in a playfull form so that the child did not know that he/she is being judged.
All objects were placed on table in the middle line of the child's body. In order to eliminate an error during examination of ear preferences the child did not receive any object in his hand so that it did not intiutively reach with the dominant hand and place to the ear on the same side of the body. During the examination the following tasks were carried out concerning the side preference during the directed activity: insertion of objects into a small hole; greeting the teddy bear; reaching for a telescope; looking into a cup and examining the bottom; looking through a key hole; looking through telescope; kicking the ball; climbing a step; standing on the

leg; checking the music on the phone; checking the watch noises; checking the noise of the sea in the shell.
Quantity (N) and percent (%) have been used for the presentation of data in qualitative and ordinal variables. The analysis of the research material was carried out in accordance to the applicable rules for the selection of statistical tests acc. to Stanisz [8]. The χ^2 Test was used to assess the relations between the tested variables. The critical level of significance was assumed to be $p < 0.05$. For the purpose of this article, the statistical package STATISTICA 12,5 was used.

Tests results

The results of the analysis were presented in table 1 which contains the frequency of upper limb, lower limb, eye and ear dominance. It takes into account the split into groups by the age and sex of the examined children.

Table 1. Frequency of occurrence (N) of side domination in particular age subgroups depending on sex

	AGE	RUl (N=88)	LUl (N=14)	UDUl (N=8)	RLl (N=88)	LLl (N=72)	UDLl (N=15)	RE (N=76)	LE (N=28)	UDE (N=6)	REa (N=76)	LEa (N=26)	UDEa (N=8)
Girls	4 (N=10)	10	0	0	4	4	2	5	4	1	8	1	1
	5 (N=13)	11	1	1	10	0	3	7	6	0	8	5	0
	6 (N=23)	22	0	1	14	3	6	16	5	2	17	6	0
	7 (N=9)	8	1	0	7	2	0	8	1	0	8	1	0
Boys	4 (N=14)	11	1	2	10	0	4	10	2	2	10	3	1
	5 (N=14)	11	1	2	11	1	2	10	4	0	10	4	0
	6 (N=16)	12	2	2	13	0	3	14	1	1	7	4	5
	7 (N=11)	3	8	0	4	4	3	6	5	0	8	2	1

RUl: right upper limb; LUl: left upper limb; UDUl: undetermined upper limb; RLl: right lower limb; LLl: left lower limb; UDLl: undetermined lower limb; RE: right eye; LE: left eye; UDE: undetermined eye; REa: right ear; LEa: left ear; BDU: undetermined ear

Subsequently, changes in the profile of lateralization in the upper limb-eye-lower limb-ear system which arose as a consequence of the development of asymmetry of particular motor and sensory organs. After a thorough analysis of all the data and a juxtaposition of the development of laterality, appropriate models of body lateralization were assigned to the children. In 39 (35%) of examined children was observed a crossed lateralization, in 36 (33%) undetermined lateralization. Right-sided lateralization occurred in 32 (29)% of children, and left-sided in 3 (3%).
A statistically significant relations (χ^2) between age and determination of domination profile ($p = 0.02969$) was demonstrated. Table 2 presents above data in individual groups depending on sex. In the group of 4-year-old girls in undetermined profile dominated for 4 of them (40%). For 5 the crossed model of lateralization was obse-

rved (50%) and for 1 homogeneous right-side model. In the same age group of boys the undetermined profile was detected for 7 of them (50%). Followed by a crossed model for 4 (28%) and a homogeneous right-side profile for 3 (22%). There was no left-side lateralization model in any of these groups.

Table 2. Distribution of side dominance among examined girls and boys

	RD (N = 32)	LD (N = 3)	UD (N = 36)	CD (N = 39)
Girls N (%)	18 (33)	0 (0)	15 (27)	22 (40)
Boys N (%)	14 (26)	3 (5)	21 (38)	17 (31)

Among 5-year-old girls the most common was right-side lateralization (5 girls = 38%). Followby a crossed model of lateralization (4 girls = 31%) and an undetermined model. In the case of examined boys the crossed model dominated for 7 (50%). Followed by right-side homogeneous model (5 boys = 36%) and an undetermined model (2 boys = 14%). Left-side model of lateralization was not found in any of these groups.
In the group of 6-year-old girls the crossed lateralization model (39%) prevails over the homogeneous right-side model detected for 7 children (30%) and undetermined also for 7 (30%). For 8 boys lateralization model was mostly non-determined, than for 4 it was right-side (25%) and heterogeneous (25%). Left-side lateralization model was not found for any child within groups.
In the oldest group of females undetermined lateralization was not observed. For 5 of them right-side model was observed (56%) and for 4 a crossed model (44%). In the male group there were 4 boys with undetermined lateralization (37%), 3 with crossed lateralization (27%) and 1 with right-side lateralization (9%). Additionaly for 3 boys a model of homogeneous left-side lateralization was observed (27%) which so far has not been observed in any of the previous group. The frequency of occurance the lateralization profiles in particular age groups divided by sex is presented in figure 1. There was no statistically significant relations between sex (χ^2) and determination of domination profile ($p = 0.16176$).

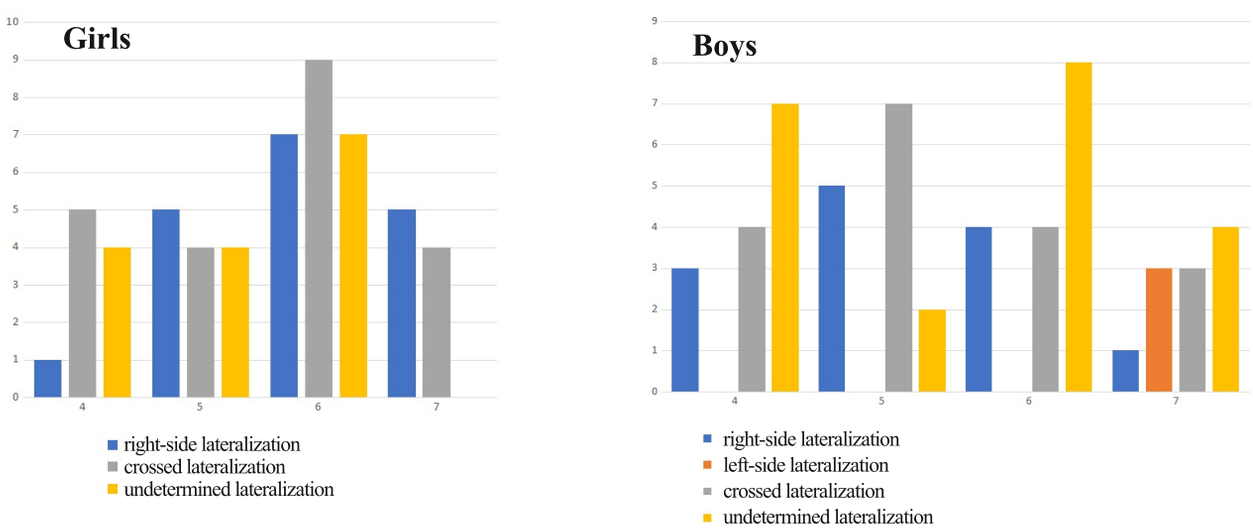

Figure 1. Frequency of lateralization profiles in the groups of examined girls and boys

Crossed lateralization occured for 39 children (35%). Figure 2. shows all combinations, which occured in this type of asymmetry including both sexes, that were noticed to have this very model. There was no statistically significant relations between ($\chi 2$) sex and crossed model ($p = 0.27477$).

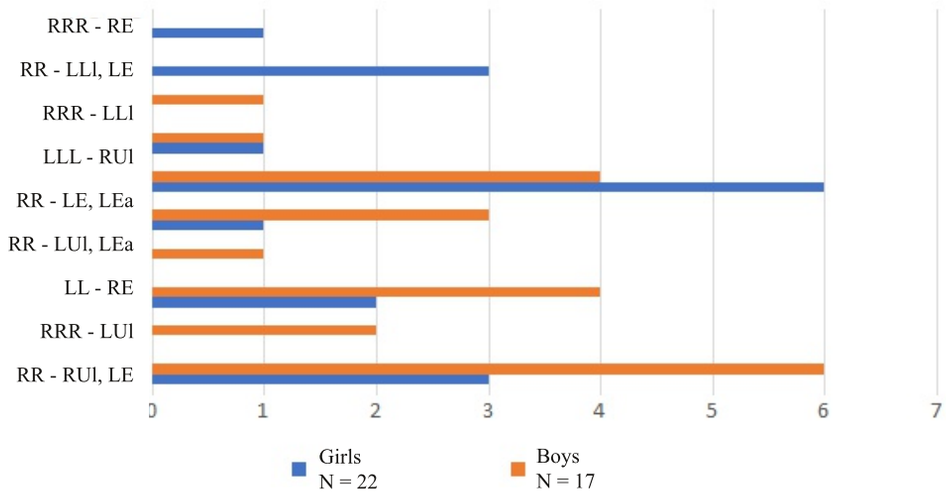

Figure 2. Variants of crossed domination in the examined group of girls and boys.
RRR: denotes a domination of three parts of the body on the right side and only one element on the left side was crossed; RR or LL: on the both sides of the body there was obserced the distribution of functional advantage of limbs or sensory organs. In accordance with the previous acronims a third; LLL: was created for the functional advantage of the left side of the bodyover the right side. In this case only one dominant limb is on the right side. On the horizontal axis the number of children with specific variant of crossed lateralization is marked.

The following table 3 shows the frequency of all combinations of lateral crossed models that occured in the study. There was also no statistically significant relation ($\chi 2$) between age and lateral crossed model ($p = 0.61193$).

Table 3. Frequency of crossed lateralization in particular age groups:
4-year-old (N = 8), 5-year-old (N = 11), 6-year-old (N = 13), 7-year-old (N = 7)

	4-year-old	5-year-old	6-year-old	7-year-old	Total
RRR - RE	3 (12)	3 (11)	2 (5)	1 (5)	9
RR - LLl, LE	1 (4)	0 (0)	1 (2)	0 (0)	2
RRR - LLl	2 (8)	1 (4)	1 (3)	2 (10)	6
LLL - RUl	0 (0)	1 (4)	0 (0)	0 (0)	1
RR - LE, LEa	0 (0)	2 (7)	1 (3)	0 (0)	3
RR - LUl, LEa	2 (8)	2 (7)	6 (15)	1 (5)	11
LL - RE	0 (0)	1 (4)	1 (3)	0 (0)	2
RRR - LUl	0 (0)	0 (0)	0 (0)	1 (5)	1
RR - RUl, LE	0 (0)	1 (4)	1 (3)	1 (5)	3

Discussion

The assessment of lateralization is often a subjective assessment of the person performing the study. Some testing methods are mainly based on observation of the child during directed activity. Among them there are proposals by Cieszyńska [9] and trials from the clinical observation sheet of Przyrowski [10]. These tasks vary in terms of the number of samples. Most of the tests available in scientific publications and books have at least 3 tests per organ to avoid accidental use of the limb or sensory organ by the child. Matejćek and Źlab [11] proposed to estimate the right-handedness quotient (IPR). Right-handedness quotient is related with using a formula prepared by them (after all motor tasks have been performer by a child) in order to express the number of right reactions as a percentage.

Wada Test is an invasive method to assess hemispherical dominance. After injection of barbiturate to the cartoid arteries psychological tests are carried out to assess the function of the examined speech and memory centres. Due to invasiveness and difficulty this method is rarely used for younger children [12].

The study presented in this article shows that boys more often than girls have undetermined lateralization of the upper limb. Girls are more likely to be a right-handed than boys while boys are more likely to be left-handed. Singh, Manjary and Dellatolas [13] made a research regarding handedness for Indian children. In their studies they found that the distribution of upper limb preferences was similar for boys and girls. It is worth mentioning that similar trends are presented in the both of these researches. The analysis shows that children aged 4-6 years often have an undetermined upper limb lateralization. For children aged 7 years similar phenomenon does not occur. In their research also for the younger group of children of the same age there was more with weak hand preference (18,2%) than in the older group aged 7-11 years (10,5%). This confirms the influence of age on the level of preference and lateralization of upper limbs. In the presented work the analysis of the direction of manual development showed that both girls and boys are dominated by the right-sided direction within the upper limb. In addition, the group of boys were more indeterminate handedness in comparison with the girls.

Conclusions on the development of body lateralization among children are also presented in the research carried out by Sobera regarding shaping and maintaining balance for children, taking into account the lateral dominance of the lower limbs [14]. The collected data showed that groups of 2-3 years old there were no significant differences between the support functions of the lower extermities. For children aged 4 years the lateralization process was developing intensively. Functional dominance of the right lower limb over the left limb was observed in the group of 5-year-olds. For 6-year-olds there was no clear domination of the one of the lower limbs during the process od stabilization of the body. According to own research children of different ages from 4 to 7 years show a similar lower limb lateralization.

This study presents that majority of children already have a certain eyedness. It also shows that examined children have similar eye lateralization. Carried out tests concerned only the preferences on the eye for the near vision. In the future it will be worth of considering whether there are corelations between dominant eye to the near and distant vision and age and sex.

Much less common in literature and empirical research is the reference to the development of auditory laterality. Very often

the laterality of the sensory organ i.e. the ear is omited in scientific researches. In acoustics and audiology the term „auditory lateralization" refers to the location of a sound source in a specific situation [15]. This may be due to difficulties in testing this structure. The most accurate will be the Listening Attention and the Auditory Lateralization Test however well calibrated audiometer, the ability to operate it and the environmental conditions (quiet room/audiometric cabine) are required. In standard testing with the use of objects as proposed by Cieszyńska [9] and which was carried out in this article, unfortunately there is a high risk of getting unreliable result because of many variables that may interfere with the evaluation proces. Any outside noise can affect the reliability of the test. On the basis of the data in table 2 it can be seen that children from the examined group show a similar ear lateralization – dominance of right ear.

Kurowski presents entirely different results of ear lateralization tests [6]. However in his research he assessed the side preference for children with dysleksia. He showed that among this group there are more children with crossed lateralization with left ear dominance. Among of children with the same type of crossed lateralization right upper limb, right lower limb and right eye dominance, we can observe domination of the left ear. The same pattern is presented by the most numerous group of children – 10 (26%) with undetermined crossed lateralization profile. It follows that the right cerebral hemisphere is responsible for hearing proces. Under normal conditions these strategies should belong to left hemisphere – requiring right ear lateralization in terms of auditory control.

Wieczorek and Świeczek showed that in the examined group of 7-year-old girls the undetermined profile of lateralization slightly dominated over the determined homogeneous one. In the group of 7-year-old boys the undetermined profile of lateralization is dominating [16]. Similar trends are noted in this research. It has been noted that children aged 5 years have determined right-side dominance profile among all examined groups. In a group of children aged 6 and 7 tears the determined right-side dominance profile is more frequent than 4-year-olds.

There is no information regarding left-side lateralization model in Wieczorek's research. In the examined group children aged 7 years have a left-side dominance profile with a frequency of 15%. Other children (aged 4-6 years) did not show this type of dominance. It means that left-side lateralization is fixed later than right-side. People aged 4 years have an undetermined dominance profile more often than others. A surprising result was noted that children aged 6 years, more often than aged 5 and 7 years showed an undetermined dominance profile. This may be the result of the fact that preschool children are introduced too quickly to the school system. Thus, children aged 5 years have more often a crossed dominance profile than other children. Other age groups present similar frequency of crossed lateralization model to each other.

A 2010 study published in Pediatrics found that two-handed children are more likely to show attention deficite hyperactivity disorder signs (ADHD) and language learning difficulties in comparison with their left-handed and right-handed peers. Children with heterogeneous domination were also more suspectible to more severe forms of ADHD compared to right-handed children with ADHD. The authors of the study also noted that children with

heterogeneous domination are more likely to develop a dyslexia [17]. In order to confirm the results obtained in this study it would be necessary to create an interdisciplinary team consisting of people with the necessary knowledge to evaluate the cognitive processes of children and children's behaviour.
All these studies and the discoveries can help teachers and health professionals to better understand and identify the problems of children who are particulary vulnerable to certain disorders.
Child's brain is not fully shaped yet which makes it more plastic. During this period it is constantly developing. Thanks to the new experiences it learns and takes shape. All the actions taken at an early stage of child's life bring much better results than in later years.

Conclusions

Evaluation of the lateralization in preschool and early school age is a very important aspect. It affects the further proper development of each child in such early age. On the basis on the presented results of the study in lateralization model for children aged 5-7 years the following conclusions could be drawn:
1. There is a relationship between sex and handiness of the examined children. Boys are more likely to be left-handed than girls.
2. There is a corelation between age and determination of dominance profile.
3. There was no relatioship between sex and crossed lateralization. Girls and boys present similar models.

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