

## FUNCTIONAL AND DYNAMIC ASYMMETRY IN YOUTH AGED 14 AND 16 YEARS (COMPARATIVE RESEARCH)

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This research purpose is an evaluation of the degree of lateralization in 14 year old youth and a comparison of the obtained results with the results of the research carried out in the same group of youth two years later (16 year olds). Effective identification of the level of lateralization is extremely significant for the practice of didactic and educational work, and it is becoming one of the priorities in the fight against difficulties in learning and eliminating developmental dysfunctions. Knowing that lateralization is a characteristic of human development, getting to know its state and determinants may be one of the basic conditions of an effective influence of the teacher.

The research was carried out in one of a number of randomly selected towns in Lower Silesia. For research purposes first grade students were selected (60 students, including 30 girls and 30 boys). Verified tests by Koszczyk and Sekita (Osiński, 2003) were used for the purposes of assessing functional and dynamic asymmetry. The research project enabled its authors to accomplish the objective of the present work. During the two years, changes occurred both in functional and dynamic asymmetry. The percentage of persons with a determined profile and a determined direction of functional asymmetry increased. Also the level of dynamic asymmetry of the examined motor abilities increased. The above described changes pertain to both the group of girls and the group of boys although their intensity was greater in the group of boys.

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*Keywords: Lateralization, functional and dynamic asymmetry, teenagers.*

### INTRODUCTION

Among the factors stimulating the proper psychophysical development in children, the importance of a diversified level of efficiency of both sides of the human body, so called lateralization, is underestimated. The term may be translated into "one sidedness" or as a function based dominance of one side of the body over the other one located on its opposite side. The dominance pertains to the upper limbs, lower limbs and paired sense organs, particularly the eyes. Lateralization is a process which is gradually intensified during the general motor development of a child. This process results in morphological and functional diversity in the development of the right and left side of the human body. Such diversity is closely connected with the functional supremacy of one of the cerebral hemispheres. Lateralization is a natural, inevitable process; a process that is characteristic of humans. It is one of the regularities of the psychomotor development of people (Spionek, 1965; Zazzo, 1974; Hurlock, 1985). The process of lateralization is usually completed around the age of 12 years (Bogdanowicz, 1992). There are children, however, whose maturity with regard to the lateralization of motor activities is delayed and is not completed at this stage of life (Zazzo, 1974). When the process of lateralization is accomplished it is usually referred to

as the asymmetry of the body. The sciences on physical education single out, e.g. functional and dynamic asymmetry. Functional asymmetry is the privileged position (motor supremacy) of one side of the body to the disadvantage of the other side of the body in the performance of everyday activities. Dynamic asymmetry is diversity existing between the limbs or organs located on the opposite side of the human body, e.g. the difference in speed, agility and other features or properties of human motricity (Koszczyk, 1991).

In the study on adults most frequent is the clear supremacy of one side of the body over the other one regarding motor and sense organs. Such a phenomenon is called unilaterally determined dominance. In the population there are also individuals with determined, although non unilateral dominance (cross dominance), with lateral dominance regarding the motor and sense organs yet on different sides of the body. Apart from those with an established dominance, there are also people without clear differences in relation to the frequency of using organs of both sides of the body. Such persons are described as bilateral. Bilateralness is not a normal phenomenon and it usually involves a delay or lack of the process of lateralization. The view that bilateral children use two sides of their body equally well is wrong. Comparative study of the efficiency of hands in children with different degrees and models of

laterality proved that the efficiency of their hands in primarily ambidextrous children is close to the efficiency of hands among "worse" children, i.e. children strongly lateralized early on (Spionek, 1985). Ambidextrousness is the least favorable formula from the point of view of children's psychomotor balance. Ambidextrous children are usually of little physical efficiency; they tend to have problems with coordination, especially when both hands are involved in the performance of precise movements. More frequently than properly lateralized children, they show spatial orientation disorders. These children have problems with learning to read and write (Spionek, 1965, 1985; Stokłosa, 1980). Difficulties in motor learning, especially in learning complex motor activities are also present (Koszczyk, 1991; Wiczorek, 2001, 2003). Also the occurrence of cross dominance may be the reason for failures at school among those students. The research showed that cross dominance in children quite often causes disorders in reading and writing which consist in confusing letters of similar shapes but of different position (letters d and b, p and b, etc.). Spionek (1965) found that among children with difficulties in reading and writing as many as 60% of cases of cross lateralization were discovered, whereas among children reading properly only 38%. This opinion is not accepted by Zazzo (1974), who claims that cross lateralization (eye - hand - cross - hand - eye) is not the reason for the above described difficulties, sometimes it accompanies them only. The contemporary research leans towards the latter concept for in the population of adults about 1/3 shows left eyedness or two eyedness and as many as around 90% right handedness, which makes the presence of cross lateralization quite common. No correlation between handedness and eyedness has been found, which indicates that these are variables independent from each other (Bogdanowicz, 1992).

The above deliberations present the essence and importance of lateralization for the normal psychophysical development of humans. Knowing that lateralization is a regularity of human development, getting to know its status, its conditions and changes is one of the basic prerequisites for the effective influence of a teacher. Identification of the level of lateralization of a child is extremely important for the practice of didactic and formative work and may become one of the tools in a struggle with difficulties in learning and in elimination of the developmental dysfunctions of a young person. The above views, opinions and data account for the objectives of our paper.

The cognitive objective of the present work is to evaluate the changes regarding lateralization during a span of two years in the life of 14 and 16 year olds. The research by Wiczorek (2001, 2003) carried out on 10 and 13 year olds showed that a significant percentage of the children in question represent a low level of body asymmetry and reveal constant changes in the size and

direction of their asymmetry. Yet, research carried out by Koszczyk and Surynt (2000) and by Surynt (2003) indicates that functional asymmetry of the hands and eyes is developed even in 7 year olds and the subsequent changes relate only to the size of the dynamic asymmetry.

With this in mind the question as to whether the process of lateralization is actually completed around the age of twelve, according to professional literature (Hurlock, 1985; Spionek, 1985), becomes more and more important, or whether due to the presence of a secular trend, lateralization has also changed its dynamics and the borderline of the final development of body asymmetry has been shifted.

The practical objective of the paper was to find out whether there is a necessity for didactical effect towards stimulating lateralization among secondary college preparatory school aged youth (14 and 16 year old students), assuming that the level of asymmetry is vital to effective learning and motor activities.

The following assumptions were made at the initial stage of research:

1. In the studied group of girls and boys, during the two years, there were no significant changes concerning the direction and profile of functional asymmetry.
2. Among the subjects significant changes concerning dynamic asymmetry took place.
3. There are dimorphic differences, among both 14 as well as 16 year olds concerning functional and dynamic asymmetry.

## MATERIALS AND METHODS OF RESEARCH

The research was carried out in one of a number of randomly selected towns in Lower Silesia (Dolny Śląsk). For research purposes first year students have been selected (60 students, including 30 girls and 30 boys). At the time of research the subjects were not younger than 13 years and 3 months of age and not more than 14 years and 2 months old. Two years later the same group of girls and boys underwent tests.

**TABLE 1**  
Morphological characteristics of examined youth aged 14-16 years

Feature		14 year old girls	16 year old girls	14 year old boys	16 year old boys
Body mass (kg)	$\bar{x}$	51.3	51.6	50.4	52.6
	SD	6.7	6.9	8.5	8.4
Height (cm)	$\bar{x}$	158.9	162.4	158.5	162.2
	SD	6.5	6.4	8.6	7.6

$\bar{x}$  - arithmetic mean, SD - standard deviation

General morphological characteristics and social and living standard assessed in the studied group of subjects. The height and body mass of the students were analysed (TABLE 1). During the two years the morphological parameters of the examined youth changed. First of all, the height of the subjects increased (girls on the average by 3.5 cm and boys on the average by 3.7 cm). The increase of the body mass within the group of girls was insignificant (mean increase by 0.3 kg) whereas in the group of boys their body mass increased by 2.2 kg on the average.

**TABLE 2**

Sequence of test trials in the study on functional asymmetry

Trial		Evaluation of activity
1.	Hand	Which hand does the subject use to greet a teddy bear with a handshake?
2.	Hand	Which hand does the subject use to draw?
3.	Eyes	Which eye does the subject use to watch the bottom of a mug?
4.	Legs	Which leg does the subject use to leap forward to cover a selected distance?
5.	Hands	Which hand does the subject use to carry a package?
6.	Eyes	Which eye does the subject use to watch the pattern in a kaleidoscope?
7.	Legs	Which leg does the subject use to kick a tennis ball at a target?
8.	Hands	Which hand does the subject use to throw a tennis ball at a target?
9.	Legs	Which leg does the subject use to make the longest jump?
10.	Hands	Which hand does the subject use to greet a teddy bear with a handshake?

Many authors believe that the education level of parents affects quality of life, which means: cultural and hygienic conditions at home and the model of living and consuming (Przewęda, 1985; Ignasiak, 1988). The majority of subjects come from a poorly educated environment. More than half of the parents (56%) have only a vocational education, 12.5% have only a primary school or basic education and only 6.6% have higher education. About 65% of the parents of the subjects regarded their financial status at home as being poor. Among them 39% of the parents are unemployed, with half of them not being entitled to any benefits.

Verified tests by Koszczyk and Sekita (Osiński, 2003) were used for the purposes of assessing functional and dynamic asymmetry. The test consists of two parts. The first part of the test determines the direction of functional asymmetry (TABLE 2) (percentage of individuals with a given sidedness) on the basis of the

observation of the free choice of the eye, hand and leg by the subject for the purpose of completing a given motor task. Following the assumption made by the authors of the test the credibility of results is higher, the more focussed on the completion of a task the subjects are, and not on the choice of the limb or eye for completion thereof. Therefore the description of the trials and the way they are carried out have been presented in the form of tasks. On the basis of obtained results the profiles of functional asymmetry in the eye - hand - leg system are developed. In the overall human population, three profiles of asymmetry may be distinguished, and they are as follows:

- a determined homogenous profile, when the tested motor and sense organs dominate on one side of the body;
- a determined non homogenous profile, known also as a cross profile, when motor and sense organs dominate, yet on different sides of the body and
- an undetermined profile, in other words a weak profile, when at least one of the examined organs does not show determined sidedness (Bogdanowicz, 1992).

In the second part of the test based on the difference in the results of tasks performed by means of the right and left upper and lower limb, the degree of dynamic asymmetry is evaluated. The evaluation refers to two motor abilities - power and speed. The employed test encompasses four tests: the tapping on the circles test for the purpose of determining the speed of manual movements, the tapping test by Fleishman to determine the speed of movements of the lower limbs, pushing the medicine ball (1 kg) in a sitting position for the power of upper limbs power and the one legged jump test from the spot to measure the power of lower limb muscles. The statistical quantity of the difference pertaining to the results of the right and the left side of the body translates into the size of the asymmetry. The study by means of the functional asymmetry test had been implemented before the study by means of the dynamic asymmetry test. The tests were carried out in accordance with a given order with the assistance of PE teachers in the school gym, with each part of a test performed during one day. The measurement of the selected morphological features, height and body mass, was made with the help of the school nurse. All acquired data was developed statistically in the computational center at the University School of Physical Education in Wrocław. The data connected with the characteristics of the environment of the examined children comes from the questionnaire for parents/guardians of the high/middle school students which was to be filled in by the parents at the beginning of the school year in the first grade.

**TABLE 3**

Lateralization profiles in groups of 14 year old girls and boys (%)

Type of lateralization profile	Examined groups	
	Girls	Boys
Determined unilateral	76.6	36.7
Determined crossed	6.7	20.0
Undetermined	16.7	43.3

**TABLE 4**

Direction of sidedness in groups of 14 year old girls and boys (%)

Examined motor or sense organ	Examined groups					
	Girls			Boys		
	KP	KL	NN	KP	KL	NN
Eye	<b>80.0</b>	20.0	0.0	<b>56.7</b>	43.3	0.0
Upper limb	<b>80.0</b>	13.3	6.7	<b>73.3</b>	0.0	26.7
Lower limb	<b>76.7</b>	10.0	13.3	<b>76.7</b>	6.7	16.6

*Legend*

KP - right side direction, KL - left side direction  
 NN - unspecified direction

**TABLE 5**

Lateralization profiles in groups of 16 year old girls and boys (%)

Type of lateralization profile	Examined groups	
	Girls	Boys
Determined unilateral	76.6	46.7
Determined crossed	16.7	40.0
Undetermined	6.7	13.3

**RESULTS****Functional asymmetry in examined groups of 14 year old girls and boys**

The comparison of 14 year old girls and boys as regards functional asymmetry showed that both its profile and direction diversified the examined groups. The girls, 83.3%, had a determined profile of functional asymmetry, whereas boys had the determined profile only in 56.7% of the subjects. Among girls with an established profile as many as 76.6% had a homogenous type of profile. Only 16.7% of the examined girls had a non established profile of functional asymmetry and among boys this was the case in as many as 43.3% of the cases (TABLE 3). Among girls, with respect to all examined motor and sense organs, the right side direction prevailed. Lower limbs turned out to be the least directed but the eyes proved to be the most directed, however. Among boys the right side direction dominated, too, yet its domination was manifested in a less vivid way

than in the group of girls. The upper limbs, however, showed themselves to be the least directed (TABLE 4). The presented research results, concerning profiles and directions of functional asymmetry in the group of girls and boys, show that in the group of 14 year old girls the process of lateralization is by far more advanced than in 14 year old boys. In the group of boys more subjects had a non determined profile and an unspecified direction of functional asymmetry. This fact indicates that the process of lateralization in the group of 14 year old boys is not finished yet. This may be connected with the later maturity of boys. For girls the time referred to in this work is already adolescence and the above discussed processes are faster.

**Functional asymmetry in the examined groups of 16 year old girls and boys (the same group examined two years later)**

The comparison of 16 year old boys and girls in connection with the profile and direction of functional asymmetry showed us that both its profile and its direction diversified the studied groups. Girls (93.3%), and 86.6% of boys, demonstrated a determined profile of functional asymmetry. Yet, an established homogenous profile definitely dominated in the group of girls (76.6%). Only 6.7% of the tested girls, and respectively as many as 13.3% of the boys, had a non determined profile of functional asymmetry (TABLE 5). The right side direction prevailed in both girls and boys in relation to all studied motor and sense organs. The least directed were the lower limbs whereas the eyes were most directed. As far as the direction of the upper limb was concerned girls had an established direction and among boys 6.7% still had an undetermined direction (TABLE 6). The presented research results concerning the directions and profile of functional asymmetry in the group of girls and boys show that within the group of 16 year olds the process of lateralization is more advanced among girls. Boys have undetermined profiles and undetermined directions more frequently as regards the asymmetry of body functions.

**TABLE 6**

Direction of sidedness in groups of 16 year old girls and boys (%)

Examined motor or sense organ	Examined groups					
	Girls			Boys		
	KP	KL	NN	KP	KL	NN
Eye	<b>80.0</b>	20.0	0.0	<b>56.7</b>	43.3	0.0
Upper limb	<b>86.7</b>	13.3	0.0	<b>90.0</b>	3.3	6.7
Lower limb	<b>83.3</b>	10.0	6.7	<b>80.0</b>	13.3	6.7

*Legend*

KP - right side direction, KL - left side direction  
 NN - unspecified direction

**TABLE 7**

Characteristics and differences in motor efficiency of right and left side of the body in 14 year old girls and boys

Feature	Side		Examined groups of 14 year olds		Student's t-test
			Girls	Boys	
Speed of movements: upper limbs [number]	P [right]	$\bar{x}$ SD	66.60 5.23	72.07 7.11	-3.39**
	L [left]	$\bar{x}$ SD	62.93 5.89	65.27 7.15	-1.38
Speed of movements: lower limbs [number]	P	$\bar{x}$ SD	57.20 4.66	60.87 7.01	-2.37*
	L	$\bar{x}$ SD	53.27 4.71	55.40 7.03	-1.39
Strength of muscles: upper limbs [cm]	P	$\bar{x}$ SD	43.27 7.58	63.40 16.79	-5.99***
	L	$\bar{x}$ SD	37.73 7.70	56.13 13.68	-6.45***
Strength of muscles: lower limbs [cm]	P	$\bar{x}$ SD	111.73 8.20	121.87 15.96	-3.09**
	L	$\bar{x}$ SD	109.23 9.14	114.57 16.01	-1.58

*Legend*

P - right side, L - left side

$\bar{x}$  - arithmetic mean, SD - standard deviation

\* - statistically significant values (number of asterisks accounts for the degree of statistical significance)

### The comparison of research results among 14 year old and 16 year old girls and boys (the same group examined two years later) in relation to functional asymmetry

The comparison of the studied groups of 14 and 16 year old youth in relation to functional asymmetry proved that changes took place, thus showing that lateralization is still at the stage of formation. Of 14 year old girls, 83.3% had a determined profile of functional asymmetry, whereas in 16 year old girls the determined profile was demonstrated by 93.3% of the female subjects. Even a bigger increase of established profiles was present in the group of boys. In 14 year olds it accounted for only 56.7% and in 16 year olds it increased to 86.6% (TABLE 3, 5). Also changes in the direction of functional asymmetry were noticed. In the group of boys a decreased number of those with an undetermined direction of functional asymmetry concerning the upper and lower limbs was observed. Among 14 year old boys it accounted for 26.7% in relation to the upper limbs and 16.6% in relation to the lower limbs. Among 16 year olds it amounted to only 6.7% as regards the upper and lower limbs. Among 14 year old girls an undetermined direction of functional asymmetry regarding the upper limbs was observed in 6.7% and of the lower limbs in

13.3% of subjects. An undetermined direction of asymmetry concerning only lower limbs accounted for 6.7% of the 16 year old girls. In groups of 14 and 16 year olds, an undetermined direction of functional asymmetry connected with the eyes was not found (TABLE 4, 6).

The results presented in this paper pertaining to the directions and profile of functional asymmetry in the group of girls and boys show that, in the group of 14 year old girls, the process of lateralization is far more advanced in comparison to 14 year old boys. Such differences are blurred when comparing the groups of 16 year olds, for in the studied group of boys a considerably bigger increase took place in the determined profiles and directions. This growth is connected with the fact that boys at the age of 14 years are still at the beginning of adolescence. For girls, however, this is adolescence and the above processes are faster. Such a big difference in relation to established profiles between the groups of 14 year old girls and boys signifies a dimorphic difference at this age. In groups of 16 year olds these differences are less visible.

### The dynamic asymmetry in the studied groups of 14 year old girls and boys

In the examined groups of 14 year old girls and boys in all measurements of motor efficiency carried out on the right and the left side of the body respectively, the dominance of the right side of the body over the left one has been found. The comparison of results obtained on the right and left side of the body between the groups of girls and boys showed many statistically significant differences. The biggest significant difference relates to the strength of muscles of the upper left and right limb (TABLE 7). Subsequently, the significance of the differences in the results from the right and left side of the body was assessed for each of the studied groups. Student's t-test for dependent features showed that in all tested abilities of motor efficiency there are statistically significant differences between the right and the left side of the body. Only the measurement of the strength of the muscles of lower limbs in girls did not show statistically significant differences. Within the examined group of girls, the highest level of dynamic asymmetry was characteristic of the strength of muscles of the upper limbs followed by the speed of movements of lower limbs. Insignificant asymmetry was reported in relation to the strength of muscles of the lower limbs. In the group of boys in connection with all studied motor abilities significant dynamic asymmetry was found. The highest level of dynamic asymmetry was attributed to the speed of the movements of the upper and lower limbs. The comparison between the examined groups as regards the size of dynamic asymmetry showed statistically significant differences in favor of the boys in all examined motor abilities except for the strength of muscles of the

upper limbs where the higher level of asymmetry was demonstrated by girls (TABLE 8).

**TABLE 8**

Student's t-test for results of right and left side of the body in the studied motor abilities of 14 year old girls and boys

Feature	Student's t-test	
	Girls	Boys
Speed of movements: upper limbs	2.96**	4.57***
Speed of movements: lower limbs	3.52**	5.00***
Strength of muscles: upper limbs	3.54**	2.85**
Strength of muscles: lower limbs	1.53	3.47**

*Legend*

\* - statistically significant values (number of asterisks accounts for the degree of statistical significance)

### The dynamic asymmetry in the examined groups of 16 year old girls and boys (the same group examined two years later)

In the examined groups of 16 year old girls and boys, for all measurements of motor efficiency carried out for the right and left side of the body the dominance of the right side of the body over the left side was found. The comparison of results obtained in tests of motor efficiency on the right and left side of the body within the groups of girls and boys showed many significant differences. The biggest significant difference was found in the strength of muscles of the upper left and right limb followed by the strength of muscles of the right lower limb (TABLE 9).

Subsequently the significance of the differences in the results of the right and left side of the body was assessed in each of the examined groups. Student's t-test for dependent features showed that in all examined properties of motor efficiency both among boys and girls there are statistically significant differences between the right and left side of the body (TABLE 10). In the examined group of girls the highest level of dynamic asymmetry was characteristic of the speed of the movements of the upper limbs followed by the strength of muscles of the upper limbs. The lowest index of dynamic asymmetry was found in relation to the strength of the muscles of the lower limbs. The highest level of dynamic asymmetry in the examined group of boys was characteristic of the speed of the movements of the lower and upper limbs. The lowest level of dynamic asymmetry was characteristic of the strength of the muscles of the upper limbs (TABLE 10). The

**TABLE 9**

Characteristics and differences in motor efficiency of 16 year old girls and boys

Feature	Side		Examined groups of 16 year olds		Student's t-test
			Girls	Boys	
Speed of movements: upper limbs [number]	P	$\bar{x}$ SD	70.20 6.40	77.93 18.54	-2.16*
	L	$\bar{x}$ SD	62.27 6.80	68.07 22.37	-1.36
Speed of movements: lower limbs [number]	P	$\bar{x}$ SD	59.60 5.52	64.00 7.45	-2.60*
	L	$\bar{x}$ SD	53.47 5.75	55.13 6.88	-1.09
Strength of muscles: upper limbs [cm]	P	$\bar{x}$ SD	45.07 8.51	64.33 16.60	-5.66***
	L	$\bar{x}$ SD	38.07 7.89	55.53 13.56	-6.10***
Strength of muscles: lower limbs [cm]	P	$\bar{x}$ $\bar{v}$ SD	113.50 8.52	125.67 13.82	-4.07***
	L	$\bar{x}$ SD	107.50 10.88	114.83 15.40	-2.13*

*Legend*

P - right side, L - left side

$\bar{x}$  - arithmetic mean, SD - standard deviation

\* - statistically significant values (number of asterisks accounts for the degree of statistical significance)

comparison between the examined groups in relation to dynamic asymmetry showed the presence of statistical differences only as regards the strength of the leg muscles in favor of boys. Another interesting item of information that comes to light in this paper is the fact that asymmetry of the strength of muscles of the upper limbs was still higher among girls.

**TABLE 10**

Student's t-test for results of the right and left side of the body in 16 year old girls and boys

Features	Student's t-test	
	Girls	Boys
Speed of movements: upper limbs	4.52***	5.23***
Speed of movements: lower limbs	3.70***	6.14***
Strength of muscles: upper limbs	3.84***	3.21**
Strength of muscles: lower limbs	2.24*	3.95***

*Legend*

\* - statistically significant values (number of asterisks accounts for the degree of statistical significance)

**TABLE 11**

Motor efficiency and its differences in 14 and 16 year old girls

Feature	Side		Examined groups		Student's t-test
			14 year old girls	16 year old girls	
Speed of movements: upper limbs [number]	P [right]	$\bar{x}$ SD	66.60 5.23	70.20 6.40	-2.49*
	L [left]	$\bar{x}$ SD	62.93 5.89	62.27 6.80	0.76
Speed of movements: lower limbs [number]	P	$\bar{x}$ SD	57.20 4.66	59.60 5.52	-2.01*
	L	$\bar{x}$ SD	53.27 4.71	53.47 5.75	-0.31
Strength of muscles: upper limbs [cm]	P	$\bar{x}$ SD	43.27 7.56	45.07 8.51	-1.34
	L	$\bar{x}$ SD	37.73 7.70	38.08 7.89	-0.48
Strength of muscles: lower limbs [cm]	P	$\bar{x}$ SD	111.73 8.20	113.50 8.82	-1.31
	L	$\bar{x}$ SD	109.23 9.14	107.50 10.89	-1.29

*Legend*

P - right side, L - left side

 $\bar{x}$  - arithmetic mean, SD - standard deviation

\* - statistically significant values (number of asterisks accounts for the degree of statistical significance)

**The comparison of results between 14 and 16 year old girls and boys (the same group examined two years later) in relation to dynamic asymmetry**

Having compared the motor effectiveness of the right and left side of the body of 14 and 16 year old girls and 14 year old boys with 16 year old boys it is possible to see significant differences. In the group of girls, motor efficiency was improved most vividly in the case of the speed of movements of the right upper limb and the speed of movements of the right lower limb. The other properties of motor efficiency have not changed in a statistically significant manner. In the group of boys motor efficiency was improved most in the speed of movements of the right upper limb, the strength of the muscles of the right lower limb, the speed of movements of the right lower limb and the speed of the movements of the left upper limb. In the case of other features of motor efficiency no statistically significant changes took place (TABLE 11, 12).

Next, the change in the level of dynamic asymmetry was checked in the examined groups of 14 year olds and 16 year olds. In the group of girls and boys the level of dynamic asymmetry increased in relation to all examined motor abilities. Statistically significant changes took place however, only in the asymmetry of the speed

**TABLE 12**

Motor efficiency and its differences in 14 and 16 year old boys

Feature	Side		Examined groups		Student's t-test
			14 year old boys	16 year old boys	
Speed of movements: upper limbs [number]	P	$\bar{x}$ SD	72.07 7.11	77.93 18.54	-4.91***
	L	$\bar{x}$ SD	65.27 7.15	68.07 22.37	-2.15*
Speed of movements: lower limbs [number]	P	$\bar{x}$ SD	60.87 7.10	64.00 7.45	-2.85*
	L	$\bar{x}$ SD	55.40 7.03	55.13 12.48	-0.37
Strength of muscles: upper limbs [cm]	P	$\bar{x}$ SD	63.40 16.79	64.33 16.60	-0.14
	L	$\bar{x}$ SD	56.13 13.69	55.53 13.56	-0.69
Strength of muscles: lower limbs [cm]	P	$\bar{x}$ SD	121.87 15.96	125.67 13.82	-3.18**
	L	$\bar{x}$ SD	114.57 16.09	114.83 15.40	-0.37

*Legend*

P - right side, L - left side

 $\bar{x}$  - arithmetic mean, SD - standard deviation

\* - statistically significant values (number of asterisks accounts for the degree of statistical significance)

of movements of the upper limbs among girls and boys and in the asymmetry of the strength of muscles of lower limbs among boys (TABLE 13, 14).

**TABLE 13**

Differences in the level of dynamic asymmetry of 14 and 16 year old girls

Feature	Student's t-test results
Speed of movements: upper limbs	-2.01*
Speed of movements: lower limbs	-0.70
Strength of muscles: upper limbs	-0.79
Strength of muscles: lower limbs	-1.26

*Legend*

\* - statistically significant values (number of asterisks accounts for the degree of statistical significance)

**TABLE 14**

Differences in the level of dynamic asymmetry of 14 and 16 year old boys

Feature	Student's t-test results
Speed of movements: upper limbs	-3.23**
Speed of movements: lower limbs	-1.58
Strength of muscles: upper limbs	-1.79
Strength of muscles: lower limbs	-2.23*

*Legend*

\* – statistically significant values (number of asterisks accounts for the degree of statistical significance)

## DISCUSSION

The determined profile and direction of the functional asymmetry of movement and sense organs is characteristic of adults with a completed process of lateralization. Having examined children and youth one may notice a significant diversity in the arrangement of sidedness. According to numerous authors (Spionek, 1965, 1985; Zazzo, 1974; Bogdanowicz, 1992) only around the age of 12–13 years the majority of children have already determined functional asymmetry in relation to the upper limbs, lower limbs and the eyes. No unilateral lateralization is considered to be a manifestation of pathology and a delay in lateralization or at least not until the age of 14 years (Bogdanowicz, 1992). The delay, even though intellectual development is normal, may cause many failures at school (Spionek, 1985). The contemporary research literature indicates that functional asymmetry concerning hands and eyes is formed even in 7 year olds and the subsequent changes pertain only to the size of the dynamic asymmetry (Koszczyk, 1991; Koszczyk & Surynt, 2000; Surynt, 2003). According to research carried out by Zazzo (1974) at the age of 6 years the same number of children demonstrate unilateral lateralization, as well as cross and undetermined lateralization. When comparing the results of 6 year olds and 14 year olds one may notice: doubling of the presence of homogenous lateralization (from 31% to 65%), more than double the decrease of undetermined lateralization (from 34% to 12%) and cross lateralization (from 35% to 22%). Having compared the results obtained by Zazzo with the ones obtained in our research on 14 year olds, it should be noted that they are close to the results concerning girls. Among boys there are much more people of an undetermined profile (43.3%) and fewer/less of a homogenous profile (36.7%). Results similar to those obtained by Zazzo have also been obtained in 16 year old boys. Only 13.3% hand us an undetermined profile. The research carried out by Wiczorek (2005), also on

14 year olds, shows the dominance of homogenous profiles among girls and boys (56%), and among the rest of the group of youth, the dominance of cross profiles in boys (21%) and undetermined profiles in girls (34%). Such a big percentage of undetermined profiles within the group of 14 year old girls does not correspond with the results obtained in our tests.

The researchers of lateralization (Spionek, 1965, 1985; Zazzo, 1974) claim that with age, in children, the number of determined profiles of functional asymmetry increases. The same regularity may be noticed when comparing the results of research carried out by Wiczorek (2001) on 10 year old children with the present research carried out on 14 year old children.

A vast majority of the examined 10 year olds had an undetermined profile of functional asymmetry (girls 72.2%, boys 71%), whereas among examined 14 year olds a determined profile dominated (girls 83.3%, boys 56.7%). In the group of 16 year old youth the number of determined profiles of functional asymmetry has increased and amounts to: girls –93.3%; boys –86.6%.

In the vast majority of the examined 14 and 16 year old youth the right direction prevailed. This result pertains to all the examined motor and sense organs of boys and girls. The dominance of the right side of the body over the left one is definite. The right side dominance is most vivid in the upper limbs, followed by the lower limbs, and is least visible in connection with the eye. The results correspond with those obtained by Mleczo and Szopa (1988) which implied that the dominance of the right upper limb amounts to 85.5%, the lower limb 80% and the eye 65–70% respectively. In the research by Wiczorek (2005) in all examined sense and motor organs the right side direction prevails, too, which is most clearly seen in relation to the upper limb (girls 95% and boys 94%).

In the research carried out by Stokłosa (1998) the most dimorphic differences in functional asymmetry have been noted among 11–12 year olds, but intersexual diversity decreased in adolescence. In our study there are dimorphic differences regarding functional asymmetry both among 14 and 16 year olds, although among the latter group they are less visible. In the study carried out by Wiczorek (2005) dimorphic differences regarding functional asymmetry are visible in terms of a cross profile and undetermined profile as well as the direction of leggedness.

In the study on dynamic asymmetry carried out in the group of 14 year old girls and boys, a clear dominance of the right side of the body over the left one was found. Similar results were obtained two years later. In 16 year old girls and boys the difference in motor efficiency between the right and left side of the body was intensified. Similar results have been achieved by Wolański and Siniarska (1986) in the study of the Polish



population aged 2 to 80 years, Koszczyk (1991) in the study of 7–10 year old children, Drabik (1984) in the study of the children of Gdańsk aged 7–15 years as well as Stokłosa (1998) in the study of 7–15 year olds. An insignificant level of dynamic asymmetry occurred only in the group of 14 year old girls in connection with the strength of the muscles of the lower limbs. The result is in agreement with the study on 14 year old girls carried out by Wieczorek (2005). In her research, asymmetry was most noticeable in the strength of hand muscles. In our study this was only the case in the group of girls. Among boys the highest level of dynamic asymmetry was characteristic of the speed of movements of the lower limbs. This is quite a specific phenomenon, for the strength of hand muscles is the fastest and the most intensely diversifying lateral motor ability. It is also the most dimorphic ability in favor of the male sex (Przewęda, 1985). In our research, dynamic asymmetry turned out to be a dimorphic property both among 14 year olds and 16 year olds. Boys demonstrated a higher level of asymmetry than girls. In the research carried out by Wieczorek (2005) no differences were found as to the size of dynamic asymmetry of 14 year old girls and boys.

## CONCLUSIONS

The research project enabled its authors to accomplish the objective of the present work. The hypotheses posed have been confirmed only in part. During the two years changes occurred both in functional and dynamic asymmetry. The percentage of persons with a determined profile and determined direction of functional asymmetry increased. Also the level of the dynamic asymmetry of the examined motor abilities increased. The described above changes pertain to both the group of girls and the group of boys although their intensity was bigger in the group of boys. Among girls as early as at the age of 14 years lateralization was highly advanced, which was demonstrated in the dominance of a determined profile and determined direction of functional asymmetry. In the group of 14 year old boys a higher level of dynamic asymmetry occurred.

Among 16 year olds an increase in the determined profile and determined direction of functional asymmetry was observed. Particularly visible changes occurred in the group of boys. Boys still dominated in the level of dynamic asymmetry of the examined motor abilities.

The obtained results indicate that during a two year period, changes pertaining to the lateralization of the body in middle school youth occurred and they indicate the occurrence of dimorphic diversity in relation to functional and dynamic asymmetry both in the group of 14 year olds and 16 year olds.

The interpretation of obtained results may be found in the environmental conditions of human development. Environment is understood as the whole of biological and financial conditions significant to life and development (Osiński, 2003). Environment affects us in the period of ontogenesis and this influence is of a special nature in childhood and youth. The environmental elements with the most significant influence on the development of a child are socioeconomic factors such as: education of parents, earnings, general level of culture, family value system, and the manner of distribution of material property (Ignasiak, 1988; Przewęda, 1985; Wolański, 1983). Within the group examined by the authors of the present paper the majority of youth came from poorly educated backgrounds. More than half of the parents (56%) had only a vocational education, 12.5% had only primary education and only 6.6% had higher education. About 65% of the parents of the examined children defined their material status at home as bad. Among them 39% of parents were unemployed including more than half of parents who were without the right to any benefits. The described environmental factors of the studied group of girls and boys have probably had a significant influence on physical development and thus on the course of lateralization.

The research results caused its authors to formulate the following conclusions:

1. Lateralization in the studied group of youth was not completed, according to the related literature, around the age of 12 years.
2. Between ages 14 and 16 years there were changes in both the direction of functional asymmetry and in the size of dynamic asymmetry. It is particularly strongly noticeable in the group of boys.
3. The obtained results may be connected with a specific environment, from which the examined youth came, in which more than half of the subjects came from families under poor financial conditions.
4. The results of the research allow its authors to state that stimulating the process of lateralization through intentional didactic activities of the teacher seems to be possible or even necessary, even in youth older than 14 years.

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**FUNKČNÍ A DYNAMICKÁ ASYMETRIE  
U MLÁDEŽE VE VĚKU 14 A 16 LET  
(KOMPARATIVNÍ VÝZKUM)  
(Souhrn anglického textu)**

Cílem tohoto výzkumu je vyhodnocení stupně lateralizace u mládeže ve věku 14 let a srovnání získaných výsledků s výsledky výzkumu provedeného u stejné skupiny mladých lidí o dva roky později (16 let). Úspěšná identifikace úrovně lateralizace je pro didaktickou a vzdělávací práci mimořádně významná a stává se jednou z priorit v boji proti poruchám učení a při odstraňování vývojových dysfunkcí. Vzhledem k tomu, že lateralizace je pro vývoj člověka charakteristická, může být poznání jejího stavu a určujících faktorů jednou ze základních podmínek účinného vlivu pedagoga.

Výzkum byl prováděn v jednom z náhodně zvolených měst v Dolním Slezsku. Za účelem provedení výzkumu byli vybráni studenti prvního ročníku (60 studentů, z nich 30 dívek a 30 chlapců). Pro vyhodnocení funkční a dynamické asymetrie byly použity ověřené testy Koszczyce a Sekity (Osiński, 2003). Výzkumný projekt umožnil autorům naplnit cíl této práce. V průběhu dvou let se jak u funkční, tak i u dynamické asymetrie projevil změny. Zvýšilo se procento osob s vyhraněným profilem a vyhraněnou stranou funkční asymetrie. Vzrostl rovněž stupeň dynamické asymetrie u zkoumaných motorických schopností. Výše popsané změny se vztahují jak na skupinu dívek, tak i na skupinu chlapců, přestože u druhé skupiny byla jejich intenzita vyšší.

*Klíčová slova: lateralizace, funkční a dynamická asymetrie, dospívající mládež.*

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***Scientific orientation***

The research purpose is evaluation of the degree of lateralization in 14 year old youth.

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