DISTRIBUTION OF CHANGES IN THE CENTER OF PRESSURE POSITION IN THE FRONTAL PLANE IN HEALTHY CHILDREN AND IN CHILDREN WITH MILD MENTAL DISABILITY PARTICIPATING IN 10-WEEK EQUESTRIAN CLASSES

Anna **MAZUR-RYLSKA**[1], Wojciech **CZARNY**[2], Marta **NIEWCZAS**[2]

1. Department of Comparative Vertebrate Anatomy and Anthropology, Faculty of Biology and Agriculture, University of Rzeszow
2. Faculty of Physical Education, University of Rzeszow, Rzeszow, Poland

Keywords:
- stabilographic parameters,
- balance,
- frontal plane,
- distribution of the COP,
- supporting plane,
- mild mental disability,
- horse riding,
- hippotherapy.

Abstract:
Balance reactions occurring at different levels of the nervous system create the mechanisms securing the proper position of the overall center of gravity (COG) of the body on the plane of support, and therefore their control ensures optimum stability margin, allowing to perform any physical activity. Humans maintaining the balance in a standing position make random movements arising from the instability of the body supported in two points. The central position of the center of gravity in humans standing on both feet moves minimally in the frontal plane, and smaller differences in the size of displacement in the frontal plane, as compared to the saggital plane, is the result of different activity in the ankle and hip.

In order to determine the nature and quality of the changes in the distribution of stabilographic parameters in the frontal plane under the influence of equestrian training we measured the range, minimum, maximum and average values of the distribution of the center of gravity pressure position (COP) in the frontal plane X in a group of healthy children and the ones with mild mental disability (MMD) participating in 10 week equestrian classes three times a week for 30 minutes. Measurement of the stabilographic parameters was made with stabilographic platform before the start of the classes and after their end in a group of healthy and MMD children of 28 people each. Statistically significant positive changes were observed in the group of healthy children except for the average value of the COP position, while the disabled children showed positive changes in the above parameters, but there was no statistical significance of these changes. However, the impact of the horse's movement shapes balancing reactions in the frontal plane in children aged 15-17 introducing the positive changes.

INTRODUCTION

A characteristic feature of the human body formed during the evolution is a vertical position of the body axis relative to the plane of support. Due to such orientation of the body in the gravitational field humans are constantly exposed to loss of balance. Only through the nervous processes responsible for the active control of postural balance are the effects of instability compensated [1]. They are associated with a very precise neuromuscular coordination allowing to maintain the balance of the body and its regulation in the standing position [7,10,13,15]. Equilibrium reactions occurring at different levels of the nervous system create the mechanisms securing appropriate position of the center of gravity (COG) of the body over the plane of support, and due to this optimum stability margin is ensured, allowing to perform any physical activity [8].

The center of gravity is maintained in a very limited area and is subject to swaying. However, thanks to the static reactions and postural adjustment reflexes we can recover the correct position. Maintaining a balanced position is primarily conditioned by the mechanism of corrective adjustments [9]. It can be immediate adaptation to changes in the sensory areas, gradual adaptation after several attempts based on previous experience and a slow learning over several days or a few weeks. Observations of several years old children indicate that initially they do not introduce systematic compensatory strategies and in response to a reduction in the surface of support they stiffen the body segments, which resembles an inverted pendulum effect [6].

MMD children are characterized by psychomotor disorder commensurate with their degree of disability. The immediate cause of mental retardation is damage to the central nervous system, which reduces the level of intelligence. Therefore, mentally disabled children have impaired intellectual, spatial-cognitive, regulatory and social adaptability processes. A large number of these children is also impaired in motor development remaining in close connection with their psychological growth, and one of the components of this development is the process of forming the balance reactions as a part of motor coordination [2,4].

The use of the horse in shaping and improving human psychomotoricity is not a new phenomenon. A rider, as a result of three-dimensional movement of the horse, is experiencing specific movement patterns. Moreover, the rhythmic movement of the horse causes rhythmic stabilization of the pelvis and trunk in the rider [12,14]. One type of the movements is the lateral movements in the frontal plane which are similar in a human being and horse in time and sequence of duration. The horse supported on the left or right pair of legs alternately lowers down the unsupported side which rocks the rider from side to side. Pelvic movements in the frontal plane in the horse are in the range 6,98º, while in humans it is 7º [3].

One of the possibilities to describe the changes of balance reactions is static posturography assessing the functional status of human vestibular system. It allows to observe the movements of the subject's center of gravity. The tested person stands on the platform with strain gauges in the corners recording the central pressure of the feet upon the surface (mapping the COG projection on the base plane), and its displacement in the frontal plane X, ie. left (-X) and right (+ X). Projection of the center of pressure on the base is, thus, recorded as a point and a dynamic parameter changing its position in time.

PURPOSE AND SCOPE OF WORK

Analysis of the problem of regulation of balance reactions concerns 28 children with mild mental disorder (MMD) and 28 healthy children participating in equestrian activities. The aim of the study is the analysis of the changes in the distribution of the center of gravity position pressure in the frontal plane X as a result of equestrian training undertaken as an alternative form of developing the balance reactions, which are an integral part of coordination abilities deciding on the performance of motor activities.

MATERIAL AND METHODS

The study group of MMD children aged 15-17 participated in horse riding activities at the Equestrian Centre "Equistro" in Wierzawice for a period of 10 weeks, three times a week for 30 minutes, while the group of healthy young people aged 15-17 did the same program in the School Equestrian Club in Nawojowa (Table 1).

Table 1. Description of study groups

Group	Weight (kg) $\bar{x}$	Height (cm) $\bar{x}$	Number
U – MMD children	60,3	164,8	28
Z- Healthy children	58,4	170,1	28

Equestrian activity program was developed in accordance with the recommendations of the Polish Society of Hippotherapy and Polish Equestrian Federation. The activities included the walk ride in the correct riding posture, as well as balance exercises in the "stand" position and walk riding. Statistical analysis was made on chosen parameters of the Bio Soft programme for the balance by recording the natural sways of the center of gravity in the open position with feet hip-width apart. Statistical analysis was performed using Statistica 8 package. We applied the descriptive statistics for the recorded variables. Analysis of the distribution of the studied features was made, which indicated lack of normal distribution and homogeneity of variance. Consequently, to detect significant intra-group changes the Wilcoxon test was used for dependent samples by performing the test twice, i.e. before the scheduled classes and after 10 weeks. Based on the measurements we specified the following parameters:

- COP-X Avg (cm) - average position of COP displacement in the frontal plane X,
- COP-X Max (cm) - maximal position of COP displacement in the frontal plane X,
- COP-X Min (cm) –minimal position of COP displacement in the frontal plane X,
- COP-X Max - COP-X Min (cm.) – range of stabilogram curve in the frontal plane X,

as well as distribution of performance value in a histogram form.

RESULTS AND DISCUSSION

Analysis of stabilographic parameters derived from testing the groups before and after the equestrian course pointed to the improvement of the maximum and minimum of the stabilogram curve sway in the frontal plane X, both in healthy and MMD children, but only in healthy children the results are statistically significant . Difference between the maximal and minimal position in both groups improved, but the change was statistically significant only in the group of healthy children. The mean position of COP practically did not change (Tab.2).

Percentage range of stabilogram curve sways in both groups indicate improved performance values, but are statistically significant in healthy children only. In the case of healthy children the greatest improvement was observed in the range of 0,0-1,0 cm sway from 15% to 27%, in the range of 1.0-2.0 cm sway, which was the dominant value (51% and 46%), the percentage difference of the change is 5%. The extreme values of this parameter decreased as a result of equestrian activities in the range of 7.0-8.0 cm and 6.0-7.0 cm indicating the improvement of the distribution of sway range values in the frontal plane (Fig.1).

The distribution of values in the changes range has a similar tendency to vary in the MMD children group where the dominating range of values was the range of sways at 1,0- 2,0 cm and 2,0- 3,0 cm where the span of changes oscillated between 29-41%. Due to the equestrian experience the difference between the extreme values of sways decreased in favour of the ranges with lower values distribution (0,0-1,0 cm from 4% to 7%; 1.0-2.0 from 41% to 29%; 6,0-6,0 cm from 12% to 4%) (fig.2).

Table 2. Stabilographic values before and after equestrian activities in the group of healthy adolescents (Z) and MMD adolescents (U)

Study group	Stabilographic parameters		COP-XAvg (cm)	COP-XMax (cm)	COP-XMin (cm)	COP-XMax-COP-XMin (cm)
Z	$\bar{x}$	Test.1	- 0,11	0,89	-1,30	2,19
		Test.2	-0,05	0,74	-0,96	1,70
	Me	Test.1.	0,12	0,62	-0,75	1,29
		Test.2.	0,14	0,59	-0,67	1,40
	S	Test.1.	1,12	0,72	1,50	1,94
		Test.2.	1,28	0,49	0,89	1,26
	Min	Test.1.	-2,29	0,34	-5,76	0,73
		Test.2	-2,77	0,28	-4,70	0,73
	Max	Test.1	1,86	2,77	-0,38	7,28
		Test.2.	1,70	2,29	-0,32	6,99
	p		0,5172	**0,0502***	**0,0509***	**0,0507***
U	$\bar{x}$	Test.1	-0,16	**1,36**	**-1,19**	**2,55**
		Test.2.	-0,16	**1,33**	**-1,10**	**2,42**
	Me	Test.1	0,12	0,97	-0,95	2,28
		Test.2	0,12	0,91	-0,99	2,18
	S	Test.1	1,50	0,92	0,55	1,09
		Test.2	1,40	1,01	0,49	1,16
	Min	Test.1	-2,73	0,37	-2,54	0,70
		Test.2	-4,52	0,48	-2,41	0,89
	Max	Test.1	2,54	3,95	-0,31	5,38
		Test.2	2,41	4,52	-0,42	5,85
	p		0,9044	0,7916	0,2439	0,0598

*statistically significant differences- Wilcoxon test p <0.05

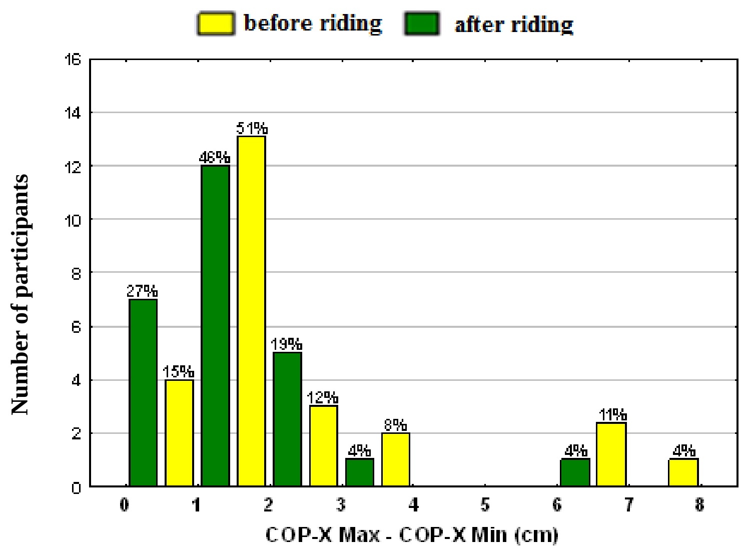

Fig.1. Distribution of COP-X Max- COP-X Min before and after equestrian training in the healthy children group

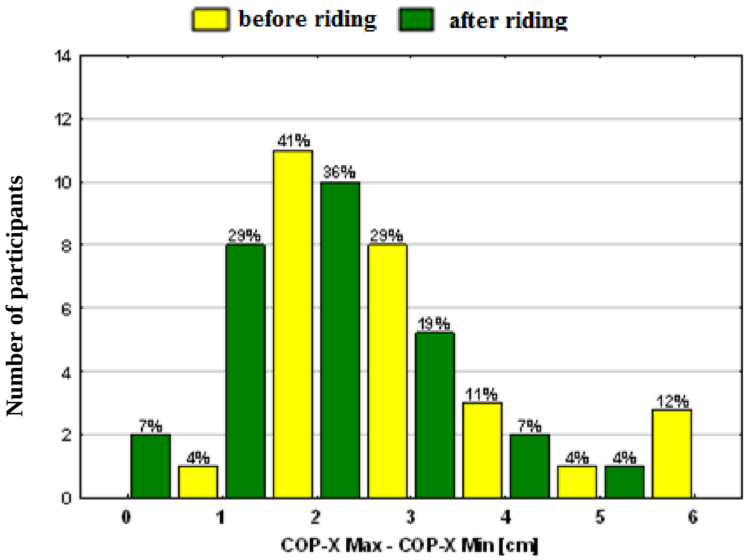

Fig. 2. Distribution of COP-X Max- COP-X Min values before and after equestrian training in MMD children group

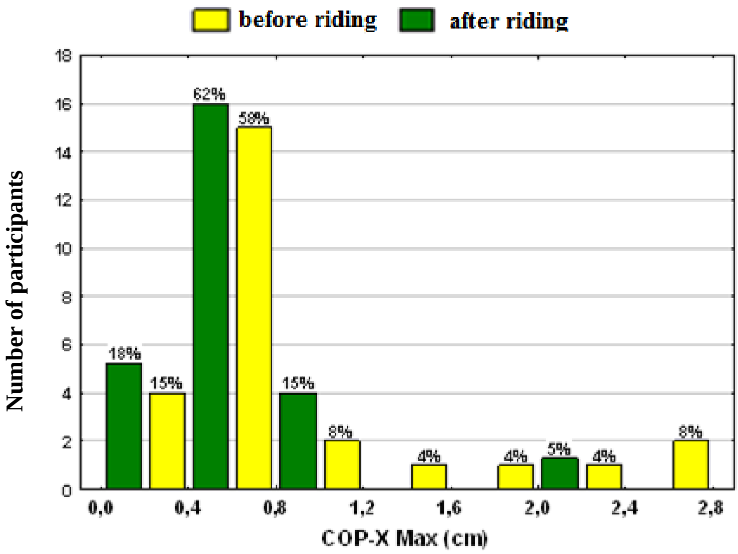

Fig.3. Distribution of COP-X Max values before and after equestrian training in the healthy children group

In the case of MMD children it was the only statistically significant positive change, however, a noticeable improvement in the parameter values as a result of riding was observed in the maximum and minimum values of sway in the frontal plane. The maximum value of COP position in the frontal plane X was observed in the group of healthy children (0.89 -0,74cm) and their handicapped peers (1.36 -1.33 cm), but this change was statistically significant only in the healthy children group (table 2).

The value distribution of this parameter indicates a greater range in MMD children (0,0-5,0 cm) than healthy ones (0,0-2,8 cm), but after the training the range distribution value decreased in both groups (Table 2). In the group of healthy children the values of lower ranges changed as follows: (0.0-0.4 cm) from 15 to 18% , (0,4-0,8cm) from 58 to 62%) and these changes are statistically significant (Fig .3)

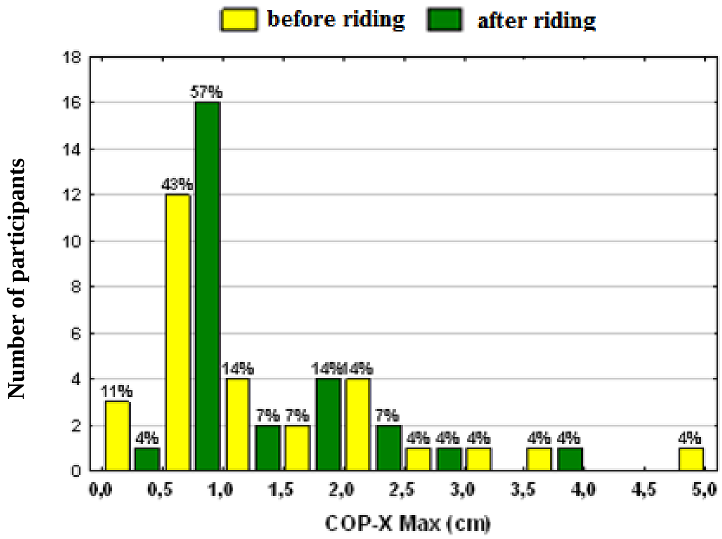

Fig.4. Distribution of COP-X Max before and after equestrian training in the MMD children group

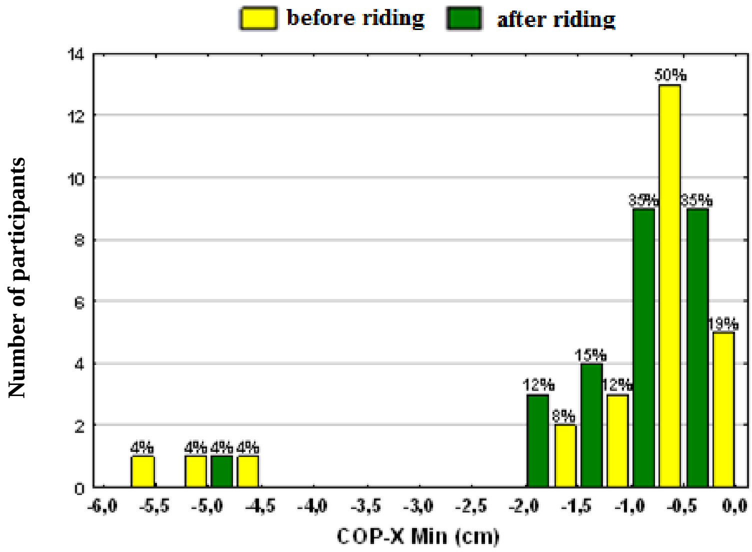

Fig. 5. Distribution of COP-X Min before and after equestrian training in the healthy children group

Distribution of maximum position of the COP in the frontal plane X also changed its values in the group of MMD children indicating the improvement, but they are not statistically significant (Fig.4). In this group the range COP-X Max 0,5-1,0 cm is most represented with 43 % before and 57 % after the equestrian training, however, in the rest of the ranges we did not notice any improvement of this parameter (Fig.4).

A similar tendency of changes is represented by the changes in the value of minimal position of the COP in the frontal plane X. A positive change in the minimal position of the COP in the frontal plane X was observed in the group of healthy children (1,30- 0,96cm) and their disabled peers (1,19-1,10 cm), but this change was statistically significant only in the healthy children group (Tab. 2). Distribution of values of this parameter in the range of 0,0-2,0 cm measured before and after the training was represented in the group of healthy children respectively by 12 people (35%) and in the group of MMD children by 4 (29%), and showed more variability in each class (Fig. 5,6). This makes it impossible to explicitly state a statistically significant improvement in the distribution of the minimal COP position in the frontal plane X in MMD children participating in equestrian activities.

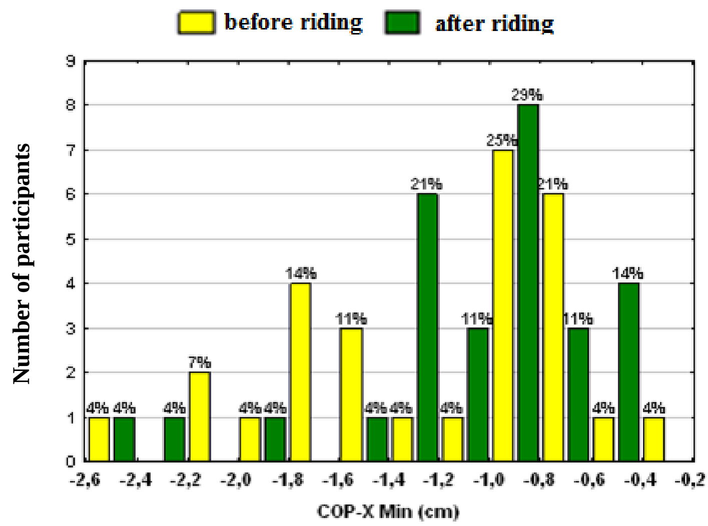

Fig. 6. Distribution of COP-X Min before and after equestrian training in the MMD children group

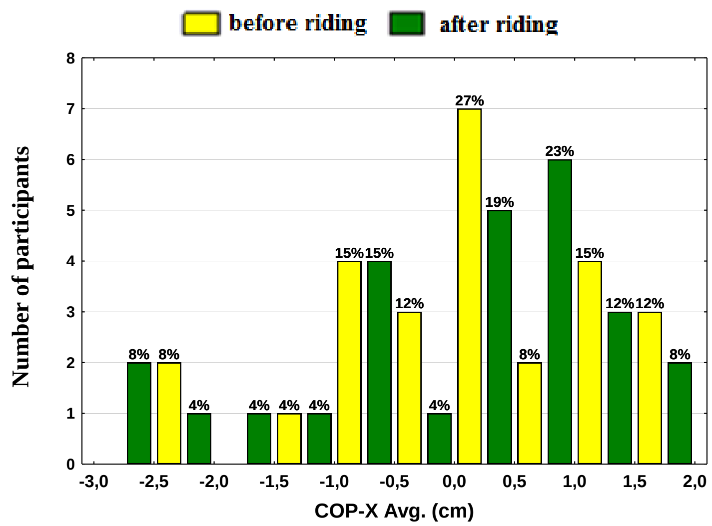

Fig. 7. Distribution of COP-X Avg before and after equestrian training in the healthy children group

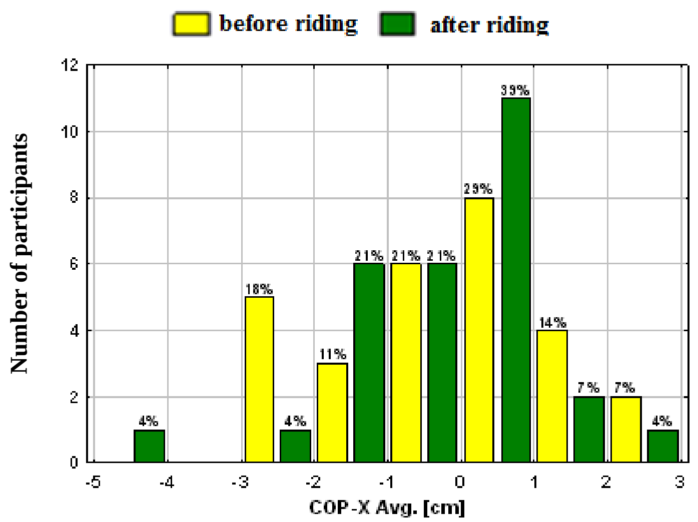

Fig. 8. Distribution of COP-X Avg before and after equestrian training in the MMD children group

Despite the observed changes in the values and distributions of minimal and maximal position of the center of gravity in the frontal plane significant only in the group of healthy children, as well as in the range of stabilogram curve sways statistically significant in both groups, the mean position of the COP in the frontal plane X did not significantly change after subjecting 56 children to riding experience (Tab. 2). Statistical measurements taken in both groups before and after training, as well as their distribution do not allow us to state any significant impact of equestrian training on their changes in the range COP-X Avg (Fig.7,8).

SUMMARY AND CONCLUSIONS

In the erect position the projection of the center of gravity of a human being remains in the restricted area of the foot support surface and keeping the center of gravity in this area does not require much muscle effort. The COG central position in a human standing on both feet moves in the sagittal and frontal planes, while smaller variations in size in the frontal plane displacement are due to the differences in the activity of the ankle, knee and hip joints [6,9]. While maintaining the balance a standing person maximally limits (stiffens) the movements in the hip joints, and the average range of motion is 7º [5]. Acetabula determine the stabilization of the pelvic girdle supporting the whole spine. The hip joint is the one which restricts movements in the standing position particularly in the frontal plane giving a stable basis to maintain balance.

Feet, on which the human body is supported, are a complex mechanical system of movement and it is different in both the frontal and sagittal plane. Considering this system in the frontal plane view, the body is joint- supported on two points shifting weight to the right and the left leg with limited movement of the hip. In addition, it moves in the ankle, shifting the foot pressure on the external or internal edge in the frontal plane [6].

From the biomechanical point of view, the degree of stability is proportional to the size of the support surface and the stability will be maximal in either direction when the vertical projection of the center of gravity is the farthest from the edge of the support plane [11]. Stability of the human body can be increased through increasing the support surface area by putting ones feet hip-wide, thus increasing the length of the quadrilateral support in the frontal plane.

Differences in balance regulation in healthy and MMD children observed in our study can indicate different functioning of the vestibular system. However, they are not the changes of high statistical significance. This may be due to the fact that in the frontal plane sways take place along the long side of the rectangular support stabilized by the hip, knee and ankle, which have a smaller range of motion in the frontal plane than in the saggital one.

The average COG position in the frontal plane X did not significantly change in the group of healthy and MMD children after horse riding and it may be explained by greater stability of reactions in the frontal plane. In the maximum and minimum values of the COP positions in the frontal plane and their distribution we observed certain improvement, i.e. reduction of these values, but statistically significant only in healthy children. Percentage distribution of the above parameter has proven beneficial, because the number of children with minimum values of the maximal COP position increased. To a lesser extent changed the minimum COP value in the frontal plane showing irregular direction of change, although the percentage distribution indicates the emergence of a large number of people characterized by values lower than before horse riding.

Changes in the value of the maximal and minimal COP position in the frontal plane X, cause improvement in the range of sways of the stabilogram curve in the frontal plane X, but statistically significant only in healthy children.

Proper regulation of balance is determined by inhibitory processes controlled by the nervous system, and even mild mental impairment is accompanied by dysfunction of the central nervous system. This may be the reason for the differences in the formation of balance reactions.

Horseback riding, due to its specific nature, affects the human body comprehensively, especially through forming the equilibrium reactions as a response to the horse movements. The three-dimensional movement initiated by the horse stimulates balance reactions and properly balances the body segments in the correct balance and rhythm. The horse, moving among others, in the frontal plane affects the human balance reactions in this plane, but due to the principle of quadrilateral support and joint function in the frontal plane, the change of equilibrium parameters does not have a wide range.

BIBLIOGRAPHY

1. Błaszczyk J.W. 1993: *Kontrola stabilności postawy ciała*.Kosmos,2: 473-486.
2. Czownicka A. 2003: *Upośledzenie umysłowe: szczególny przypadek zaburzenia rozwoju.* [in:] A. Strumińska (ed.) Psychopedagogiczne aspekty hipoterapii dzieci i młodzieży niepełnosprawnej intelektualnie. P W R i L, Kraków, 47–65.
3. Freeman G. 1992:*Assessment of the elient In hipotherapy*. [in:] B. Engel (ed.) Therapeutic Riding programs: Instruction and Rehabilitation. Barbara Engle Therapy Services, Durango, CO.
4. Gruszczyńska T.2003: *Z badań nad rozwojem sprawności fizycznej uczniów lekko upośledzonych umysłowo.* [in:] Z. Kazanowski, D. Osik-Chudowolska (ed.) Integracja osób niepełnosprawnych edukacji i interakcjach społecznych. Publ. UMCS, Lublin, 179–186.
5. Golema M. 2003: *Wielkość przemieszczeń części ciała człowieka utrzymującego równowagę.* Studia i monografie. Politechnika Opolska, Opole,148:75-128.
6. Golema M: 2002: *Charakterystyka procesu utrymywania równowagi ciała człowieka w obrazie stabilograficznym*. AWF Wrocław, 10-129.
7. Hoffer JA. 1982:*Central control and reflex regulation of mechanical impedence: The basis for a unified motor-control scheme*. Behav Brain Sci, 5: 548–549.
8. Iwankiewicz S, Pośpiech L, Fraczkowski K, Iwankiewicz J.1991: *Sterowanie postawą i równowagą.* [in:] M. Nałęcz (ed.) Biosystemy. W K i Ł, Warszawa,1: 138–158.
9. Juras G.2003: *Koordynacyjne uwarunkowania procesu uczenia się utrzymywania równowagi ciała*. AWF Katowice, 23–35.
10. Milde K, Tomaszewski P, Sienkiewicz-Dianzenza E, Wiśniewski A. 2007 :*Równowaga statyczna dziewcząt z zespołem Turnera*, Wychowanie Fizyczne i Sport, 51 (1):17–19.
11. Riach C, Starkes J. 1993: *Stability Limit sof Quiet Standing Postura Control in Children and Adults*. Gait & Posture,1: 105-112.
12. Strauß I. 1996: *Neurofizjologiczna gimnastyka na koniu*. Fundacja Hipoterapia, Kraków.
13. Tarnecki R, Zawadzki T, Kałużny P. 1991: *Neuronalne mechanizmy organizacji i koordynacji aktów ruchowych.* [in:] M. Nałęcz (ed.) Problemy biocybernetyki i inżynierii biomedycznej. Biosystemy, Wyd Kom i Łącz, Warszawa,1.
14. Von Dietze S. 2007: *Równowaga w ruchu*. Galaktyka, Łódź.
15. Wilczyński J. 2005: *Integracja sensoryczna w reedukacji posturalnej*. Wychowanie Fizyczne i Zdrowotne,3: 8–12.