DISTRIBUTION OF DISPLACEMENT OF THE CENTER OF PRESSURE (COP) IN FRONTAL PLANE IN HEALTHY AND MILDLY MENTALLY DISABLED CHILDREN PARTICIPATING IN 10-WEEK EQUESTRIAN TRAINING

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

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

Key words:
- stabilographic parameters,
- balance,
- frontal plane,
- position of COP,
- supporting surface,
- mild mental disability,
- horse riding,
- hippotherapy.

Abstract:
The balance reactions functioning on different levels of the nervous system create the mechanisms supporting the proper positioning of the center of gravity (COG) of the body against the supporting surface, which respectively enable the optimal limit of stability allowing various motor activities. A human sustaining balance in a standing position performs random movements resulting from the body instability supported by two points. The mid position of the center of gravity in the standing on both feet position is moving minimally in the frontal plane, and smaller differences in the frontal plane displacement result from different activity in the ankle and hip joints. To establish the character and quality of changes of stabiligraphic parameters in the frontal plane affected by equestrian training we measured the range, minimal, maximal and middle values of COP position in frontal plane X in the group of healthy and mildly mentally disabled children participating in a 10-week 30 minute equestrian training three times a week. A stabiligraphic platform was applied to measure the parameters and they were taken before and after the training in both groups 28 people each. Statistically significant changes were registered in the group of healthy children, but for the middle COP values, while in the group of disabled children we observed a positive change of these parameters, however, is was not statistically significant. Nevertheless, the horse movements develop useful balance reactions in the frontal plane in children at 15-17 years old resulting in positive changes.

INTRODUCTION

The characteristic feature of the human body developed in the evolutionary process is the upright position of the body axis with reference to the supporting surface. This orientation of the body in the gravitational field threatens permanent loss of balance. And only due to the nervous processes controlling the balance of the posture does a human body compensate the results of instability [1]. They rely on very accurate nervous-muscles coordination enabling maintaining the body balance and its adjustment in the upright position [7,10,13,15]. Balance reaction taking place on different levels of the nervous system create the mechanisms maintaining the proper COP position of the body against the supporting surface, respectively allowing the optimal level of stability to perform various movements [8].

The body COG is maintained in a very limited area and sways permanently. However, due to the static reactions and positioning reflexes it is possible to regain a proper position after a sway. Maintaining of a balanced posture is the effect, first of all, of the functioning of the correction mechanism [9]. It can be an instant adaptation to a change in the context of the sensory mechanism, a gradual adaptation after a few attempts based on previous experience, and slow learning within a few days or weeks. Observations of young children indicate that initially they do not apply systematic compensation strategies, and their reaction to the reduction of the supporting surface is rigidity of body parts resembling the principle of inverted pendulum [6].

Mildly mentally disabled children have psycho-motor scarcity adequate to the level of their disability. The immediate reason of mental disability is injury of the central nervous system leading to the decrease of intelligence. Respectively, children with mental disability show violation of the intellectual processes, spacio-cognitive, executive and social adaptation abilities. Majority of these children also show motor disorders which are in direct connection with their psychological development, and one of the components of this development is the development of balance reactions as components of motor coordination [2,4].

The use of a horse in shaping and developing the psycho-motorics of a human is not new. The rider, in the effect of a three-dimensional movement of a horse, experiences specific movement patterns in practice. The rhythmical movement of a horse also causes the rhythmical stabilization of the rider's pelvis and torso [12, 14]. Side movements in the frontal plane are one type of the movements which are similar in the human and the horse in time and sequence. The movements of pelvis in the frontal plane of the horse are in the range of 6.98º, and of the human it is 7º [3].

One of the possibilities of describing the balance reactions is static posturography evaluating the efficiency of the human balance system. With its application we can register the displacement of COG of the subject. The subject stands on the platform with tensometric sensors located in the corners and registering the center of pressure of the feet onto the platform (reproducing the projection of COG onto the base platform), as well as its displacements, among others, in the frontal plane X, i.e. left (-X) and right (+X). Projection of COP onto the base is therefore registered as a point and as a dynamic parameter changing its position in time.

PURPOSE AND SCOPE OF THE WORK

Regulation of balance reactions was tested on 28 children with mild mental disorder and 28 healthy children participating in equestrian training. The purpose of the work is to analyze the mean values of COP displacements as a result of horse riding training treated as an alternative form of acquiring the balance reactions, which are an integral part of coordination responsible for movement activities.

MATERIAL AND METHOD

The research group is 28 mildly disabled children aged 15-17 participating in hippotherapy training in the horse-riding center „Equistro", Wierzawice, for about 10 weeks, three times a week per 30 minutes, while the group of healthy children was doing the same program in the school horse-riding club in Nawojowa (Tab. 1).

Table 1. Description of groups participating in the training

Horse-riding group	**Weight (kg)** $\bar{x}$	**Height (cm)** $\bar{x}$	**Number**
U - Children with mild mental disability	60.3	164.8	28
Z - Healthy children	58.4	170.1	28

The training program was designed according to the recommendations of the Polish Hippotherapy Society and Polish Equestrian Society. The training included the walk riding in the correct riding posture and doing the balance exercises during the stop position and the walk. The statistic analysis was made for the selected parameters of the Bio Soft program for the balance, which registered the natural COG sways in the open position with feet at the pelvis width. The statistic analysis was made with the Statistica 8 package. The descriptive statistics of the registered changes was used. We also analysed the distribution of the tested features, which indicated the lack of regular distribution and homogeneity of variance. In view of this, the Wilcoxon test was used to trace the significant changes inside the group for the dependent samples with double tests before the scheduled practice and 10 weeks after. Basing on the measurements we characterized:

- COP-X Avg (cm)- average position of center of pressure COP in frontal plane X,
- COP-X Max (cm) – maximal position of center of pressure COP in frontal plane X,
- COP-X Min (cm)- minimal position of center of pressure COP in frontal plane X,
- COP-X Max - COP-X Min (cm.) - range of sways of stabilogram curve in frontal plane X, and distribution of the efficiency level in the form of histogram.

RESULTS AND DISCUSSION

Analysis of the stabilographic parameters received in the groups before and after the equestrian training shows improvement of maximal and minimal sway of the stabilogram curve in frontal plane, in both healthy children and children with mild mental disability, but only the healthy children's results are statistically relevant. The difference between maximal and minimal positions also improved in both groups, but the statistically relevant improvement was observed only in the healthy children. Values of the average position of COP did not change in any way (Tab.2).

Table 2. Values of stabilographic parameters before and after equestrian training in the group of healthy children (Z) and mildly mentally disabled children (U) (*statistically relevant differences – Wilcoxon test p<0.05)

Research 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

The percentage distribution of the range of sways in the stabilogram curve in both groups indicate the improvement in the values, but are statistically significant only in the healthy children. In the healthy children group the biggest improvement was noted in the range of sways 0.0-1.0 cm from 15% to 27%, in the range of sways 1.0-2.0 cm, which was a dominating value (51% and 46 %), the percentage difference of changes is 5%, the marginal values of this parameter decreased as a result of equestrian training within the range of 7.0-8.0 cm and 6.0-7.0 cm indicating the improvement in the distribution of sway values in the frontal plane (Fig.1).

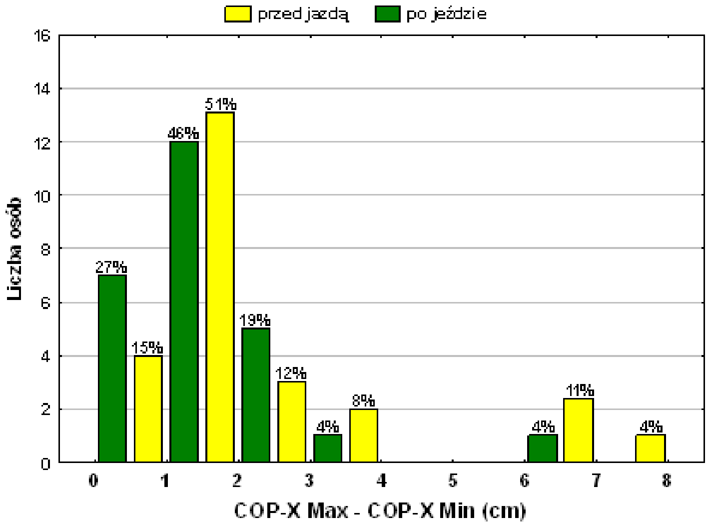

Fig. 1. Distribution of values COP-X Max-COP-X Min before and after equestrian training in the group of healthy children.

A similar tendency of the changes in the distribution of the values of changes was noted in the group of mildly mentally disabled children, where the dominating range of values was the range of sways 1.0- 2.0 cm and 2.0- 3.0 cm, where the scope of changes fluctuated between 29-41%. As a result of equestrian training the difference between the marginal values diminished in favour of the lower value ranges (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).

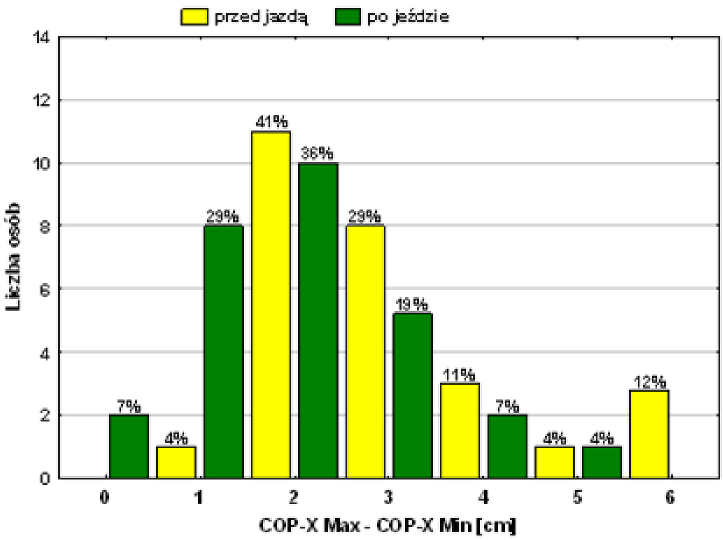

Fig. 2. Distribution of values COP-X Max-COP-X Min before and after equestrian training in the group of mildly mentally disabled children.

In the group of disabled children it was the only statistically relevant positive change, however, noticeable improvements in the values of the parameters resulting from equestrian training were noticed for the maximal and minimal sway values in the frontal plane. Maximal value for COP position in the frontal plane X was noted in the healthy children group (0.89-0.74cm) as well as their disabled peers (1.36 -1.33 cm), however, it was a statistically valid change only in the healthy group (Fig.2).

The distribution of this parameter shows a broader range in disabled children (0.0 – 5.0 cm) than in the healthy ones (0.0 – 2.8 cm), however, after the training the value of the distribution ranges decreased in both groups (Tab.2). In the healthy group of children the lower value ranges changed (0.0-0.4 cm) from 15 to 18%, (0.4-0.8cm) from 58 to 62% and these are statistically significant changes (Fig.3).

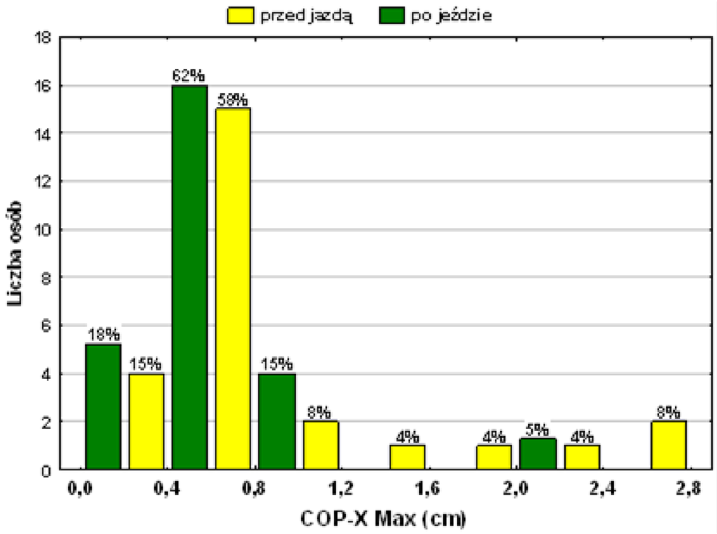

Fig. 3. Distribution of values COP-X Max before and after equestrian training in the group of healthy children.

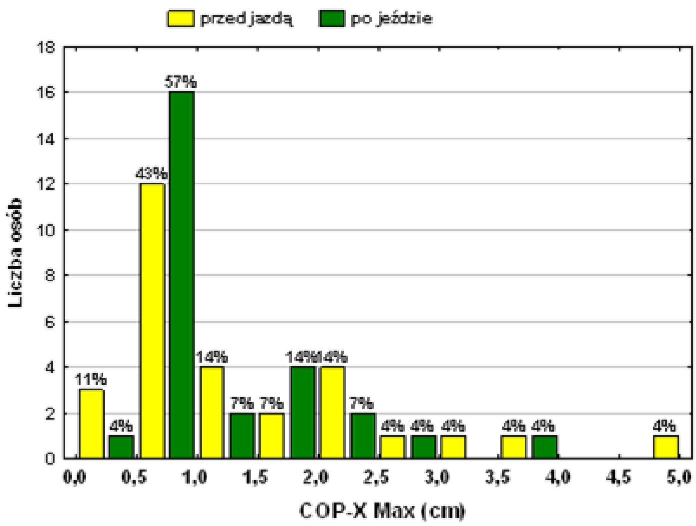

Fig. 4. Distribution of values COP-X Max before and after equestrian training in the group of mildly mentally disabled children.

Distribution of the maximal value of the COP position in the frontal plane X also changed in the group of disabled children indicating improvement, but it is not statistically relevant (Fig. 4). In this group, the range of COP-X Max 0.5-1.0 cm values is most represented with 43 % before and 57 % after the equestrian training, however, the rest of the values classes do not show improvement of this parameter (Fig. 4).

A similar tendency is seen in the changes of minimal values of the position of COP in the frontal plane X. The positive change of the minimal position of COP in the frontal plane X is seen in the group of healthy children (1.30- 0.96cm), as well as their disabled peers (1.19-1.10 cm), however, it was a statistically relevant change only the healthy group (Tab. 2). The distribution of values of this parameter in the range 0.0-2.0 cm taken before and after the training was represented in the healthy group by 12-35 % children, and in the disabled group by 4 and 29 % revealing bigger variability in specific classes (Fig. 5,6). This fact unables to show a statistically relevant improvement in distribution of the minimal position of COP in the frontal plane X in disabled children participating in equestrian training.

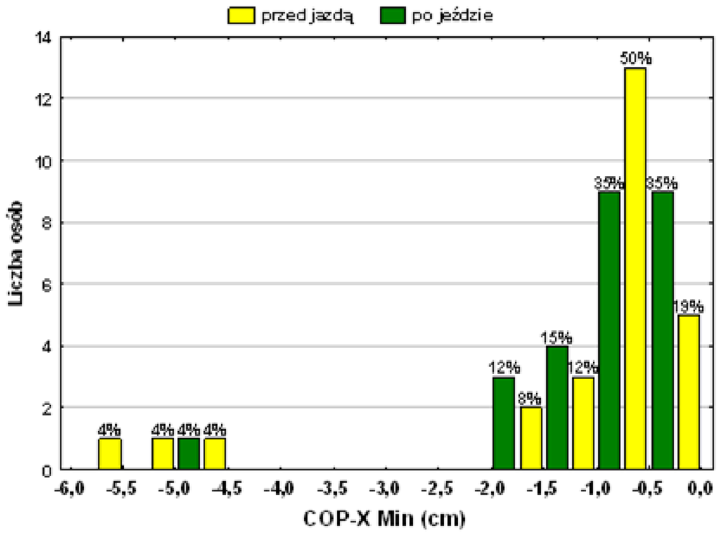

Fig. 5. Distribution of values COP-X Min before and after equestrian training in the group of healthy children.

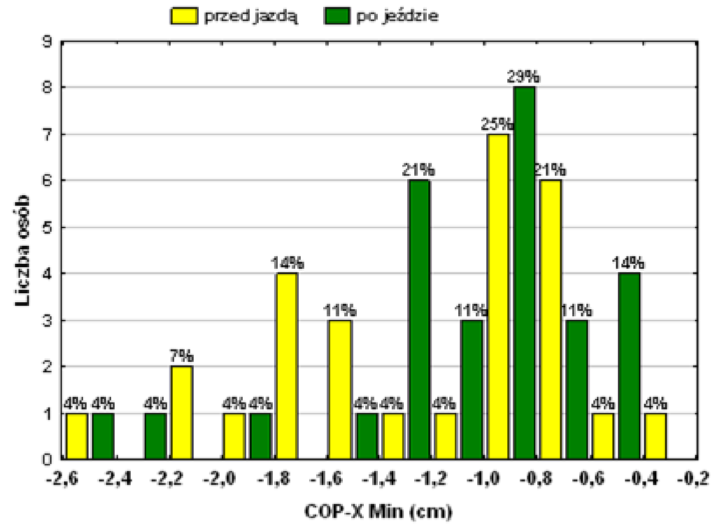

Fig. 6. Distribution of values COP-X Min before and after equestrian training in the group of mildly mentally disabled children.

Despite the changes in the values and distributions of minimal and maximal position of the center of gravity in the frontal plane relevant only in the group of healthy children, as well as in the range of the stabilogram curve sways statistically relevant in both groups, the average position of the pressure of the center of gravity COP in the frontal plane X did not show a statistically relevant change in the study of 56 children after equestrian training (Tab.2). Both, the statistic data from the two groups before and after the training, and their distribution, do not provide enough evidence of significant influence of equestrian training on their changes in the range COP-X Avg (Fig.7,8).

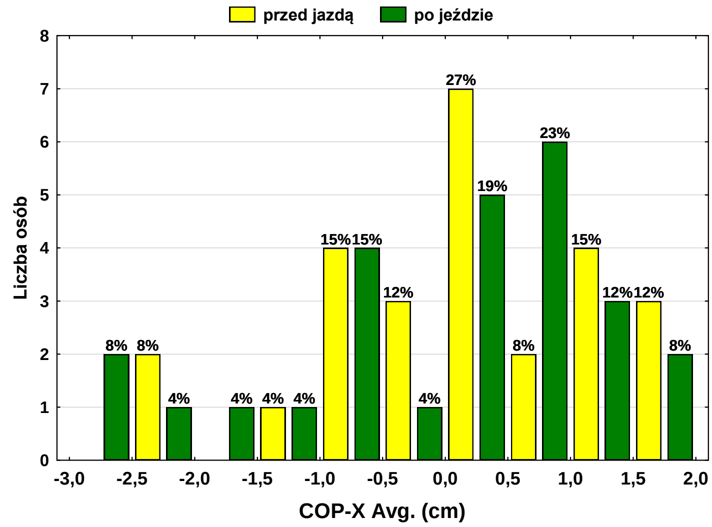

Fig. 7. Distribution of values COP-X Avg before and after equestrian training in the group of healthy children.

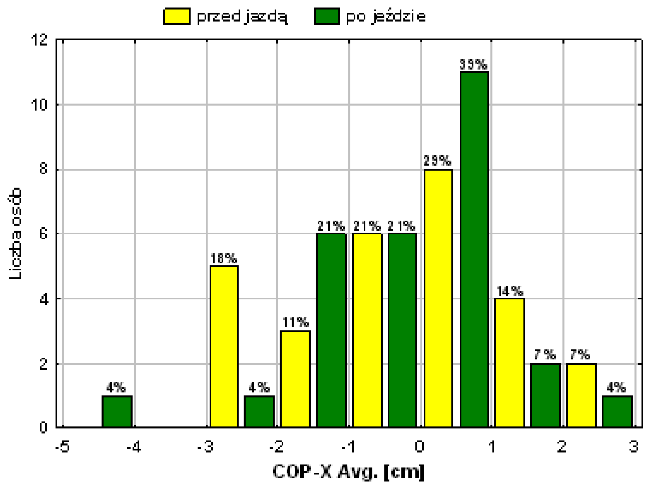

Fig. 8. Distribution of values COP-X Avg before and after equestrian training in the group of mildly mentally disabled children.

SUMMARY AND CONCLUSIONS

In the upright position the projection of the human center of gravity remains in a clearly determined feet support area, and maintaining the COG within this area does not demand much muscle effort. The center of gravity in standing on both feet position is moving in the frontal and sagittal planes, while smaller differences in displacements in the frontal plane result from different activity in the ankle, knee and hip joints [6,9]. Maintaining the balance in a standing position the subject maximally limits (stiffens) the movements in hip joints, and the average range of movement is 7º [5]. The acetabular cups determine the stability of the pelvic brim supporting the whole backbone. On top of that, the hip joint is the one which, especially in the frontal plane, restricts the movements in the standing position creating the stable base for the balance.

Feet supporting the human body are a complicated mechanical system of movement and it is different in the frontal and sagittal planes. Looking at this system in the frontal plane, the body is supported on joints in two points shifting the body weight onto right and left leg with limited movements of the hip joint. Furthermore, it makes movements in the ankle joints shifting the foot pressure onto the outer or inner edge in the frontal plane [6].

From the biomechanics point of view, the level of stability is proportional to the supporting surface, and the stability will be maximal in every direction if the vertical projection of the center of gravity is the farthest from the edge of the supporting surface [11]. Human stability can be increased by increasing the supporting surface when keeping your feet hip-width apart, thus increasing the length of the quadrangle of support in the frontal plane.

Observation of the difference in the regulation of body balance in healthy and mildly mentally disabled people indicate different functioning of the balance system. However, those are not the changes of great significance. It can be explained by the fact that in the frontal plane the sways go along the longer side of the quadrangle of support stabilized by the hip, knee and ankle joints which have a lower range of movements in the frontal plane than in the sagittal one.

The average position of the center of gravity COP in the frontal plane X did not change significantly in both, the healthy children group and in the mildly mentally disabled one after horse riding, what can be the effect of stronger stabilization of balance reactions in the frontal plane. In the case of maximal and minimal values of the center of gravity position COP in the frontal plane, as well as their distribution, there was observed improvement, that is reduction of these values, however, statistically significant in the healthy children. The percentage distribution of this parameter appeared to be useful, since there increased a number of children with minimal values of maximal position of the center of pressure. In smaller degree there was reduced the minimal value of the COP position in the frontal plane showing irregular vector of changes, while the percentage distribution of this value indicates a bigger amount of people with lower values than before the horse riding.

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

Proper regulation of the balance is conditioned by the inhibition processes controlled by the central nervous system, and the mental disability, even the mild one, is accompanied by the disfunction of the central nervous system. It can be the reason of differences in the possibilities to develop balancing reactions.

Horse riding, due to its specific nature, has a complex influence on the human body, first of all, developing the balance reactions stimulated by the movements of the horse. Three dimentional movement generated by the horse stimulates the balance reactions, properly balances the segments of the body in the proper balance and rhythm. The horse, moving, among others, in the frontal plane, affects the balance reactions of the human in this plane, however, due to the quadrangle supporting principle and functioning of the joints in the frontal plane, the change of the balance parameters does not have a broad scale.

BIBLIOGRAPHY

1. Błaszczyk J.W. 1993: *Kontrola stabilności postawy ciała*.Kosmos,2: 473-486.
2. Czownicka A. 2003: *Upośledzenie umysłowe: szczególny przypadek zaburzenia rozwoju.* [w:] A. Strumińska (red.) 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*. [w:] B. Engel (red.) 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.* [w:] Z. Kazanowski, D. Osik-Chudowolska (red.) Integracja osób niepełnosprawnych edukacji i interakcjach społecznych. Wyd. 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.* [w:] M. Nałęcz (red.) 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.* [w:] M. Nałęcz (red.) 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.