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Quality of body posture and postural stability in people with intellectual disability playing volleyball

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Purpose: The quality of body posture and its balance depends on the efficiency of the receptors, the good work of the central nervous system integrating and coordinating the postural system and the effective musculoskeletal system. Physical activity of people with intellectual disability can stimulate the processes of improving the posture and its postural stability, improving the quality of life. *Methods*: The study was conducted in 2017. 20 randomly selected volleyball players with intellectual disabilities and 10 healthy players took part in it. Body posture was recorded using a photogrammetric system. To evaluate the use of the Frohner Posture Index and the Dolphens classification, stability of the posture was assessed on the Zebris FDM power plate, analyzing the basic stabilographic parameters sway path and sway area. *Results*: Athletes with intellectual disabilities had significantly poorer posture and body balance than healthy players. There were no differences in postural stability between the groups studied. Some linear correlations were found between the quality of posture and balance and stabilographic variables. *Conclusions*: Incorrect postural patterns, observed in people with intellectual disabilities, require the development of special recovery programs. Qualified physical activity can help them improve their balance systems, reducing the risk of falls and injuries. The lack of the possibility of an unequivocal relationship between the quality of body posture and its stability requires research on a larger research material. New evaluation methods used (Frohner Posture index and Dolphens classification) confirmed their usefulness and gave new possibilities of application in postural research.

Key words: *posture quality, balance, intellectual disability, Special Olympics, physical activity*

1. Introduction

It is assumed that intellectual and developmental disability (IDD) includes the range of various conditions caused by genetic, neurologic, dietary, social, traumatic or other factors occurring prior to or at birth, or during the development since childhood to brain maturity, which affect the intellectual development of a person [9]. In consequence, individuals with intellectual disability (ID) show less precision and less locomotor abilities, and have greater problems with sensory integration [7]. As a result, people with intellectual disability prefer sitting [7]. This may be the factor contributing to the occurrence of locomotor disorders. Additionally, people with ID are particularly prone to disturbed functioning of the balance mechanisms and mobility disorders due to the potential development of deficits in posture, mobility skills and daily life [15]. Incorrect performance of everyday

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activities results in an unwanted increase of loads on the spine, which in turn translates into frequent pains and postural disorders.

Properly designed and administered physical activity may be the factor that could prevent these negative consequences. The ever more popular Special Olympics movement plays an important role here. Participation in the Special Olympics enables people with intellectual disability to improve their daily functioning [22]. It also positively stimulates the development of identity and values among the participants. Precisely designed regulations and requirements in each discipline adapted to the types and degree of disorders allow these people to engage in sport competitions. The goal of it is their physical and social development. Thanks to it, people with ID can acquire new skills, overcome their personal limitations and become open and confident members of the society [22]. An important aspect of this integration are unified disciplines where people with ID take part with people without disabilities as their partners; the role of partners is precisely determined by sport regulations. All the sport and other programs create conditions to improve the motor functions and everyday functioning of persons with ID [16].

During the original study, the postural quality of volleyball players with intellectual disability and the efficiency of postural control mechanisms were evaluated. To evaluate the postural quality, the photometric method was used. It is a simple and relatively inexpensive method of assessing the body posture [13], and its reliability and repeatability has been described many times [18]. The method used to assess the postural control was one of the classic ones, namely, static posturography. We must admit that there is an ongoing discussion about optimization of the method, technique and interpretation of posturographic data. Another difficulty is the selection of feasible and reliable tests that can be performed on people with ID [4]. There are some ongoing research into new ways of reliable evaluation of the postural stability, that would combine static and dynamic balance [9], the use of virtual reality [20] or new methods of analyzing of stabilometric signal which would reveal clear relations between the sways and postural stability [4], [19]. Also, the ways are sought to process the signals recorded during the stabilographic tests to enable easier interpretation [2], [20]. Apart from the static stabilography with the use of force plate, the clinical practice still uses tests assessing the balance in the functional way, for example: Up&Go test, Berg Balance Scale or Tinetti test, which enable observation of movements in the conditions of postural challenges.

The objective of the study was to evaluate the quality of posture and postural stability in volleyball players with intellectual disability.

2. Materials and methods

Materials

Tests were performed in September 2017 in Katowice, during the Special Olympics European Unified Volleyball Tournament, part of the Healthy Athletes Special Olympics project. The sample consisted of 20 men with intellectual disability who participated in the tournament. They were selected randomly. The control group consisted of 10 non-disabled partners. The age of the sample ranged between 22–34 years ($X = 26.6$) and of the control group age was 17–34 years ($X = 24.3$). The characteristics of the basic anthropometric variables in both groups is presented in Table 1.

Table 1. Compilation of the arithmetic mean (X), standard deviation (SD), variation coefficient (V%) of body mass and height in the studied groups

Studied variable	Sample $n = 20$			Control group $n = 10$		
	X	SD	V%	X	SD	V%
Body mass [kg]	77.4	14.16	18%	87.9	10.01	11.39%
Body height [cm]	181.3	9.15	3.7%	183.4	6.85	5.1%

As for the age and basic anthropometric data (weight and height), the respondents in both groups showed normal distribution of the analyzed variables and small individual dispersion of the results, what is proved by the values of standard deviations and variation coefficients. No significant variation regarding the height between the studied groups was observed. However, the body mass in the control group was higher ($t = 2.271$, $p = 0.0321$), which was a statistically significant difference.

Methods

The body posture was registered by means of the Photographic Postural Assessment System manufactured by the OPIW company (Opolskie Przedsiębiorstwo Innowacyjno-Wdrożeniowe). To assess the postural quality, the Frohner Posture Index was used [17], where the value ranging 1–1.3 means the balanced posture, <1 means flat back posture, and > 1.3 means overly increased curves. The method of calculating the indicator is presented in Fig. 1.

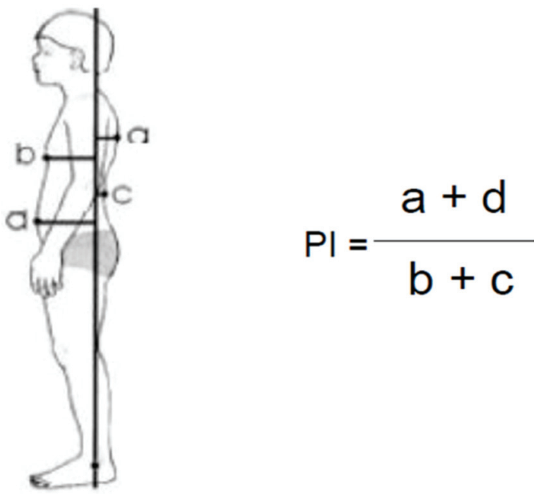

Fig. 1. The method of calculation
of the Frohner Posture Index [17], [19]

The second method used was Dolphens classification [11]. It divides the body posture into three types:

a) neutral – the vertical line applied to the posterior body surface touches the body at the level of thoracic kyphosis and buttocks (Fig. 2A).
b) sway-back – the vertical line touches the body at the thoracic kyphosis level (Fig. 2B).
c) lordosis – the vertical line touches the body at the buttocks level (Fig. 2C).

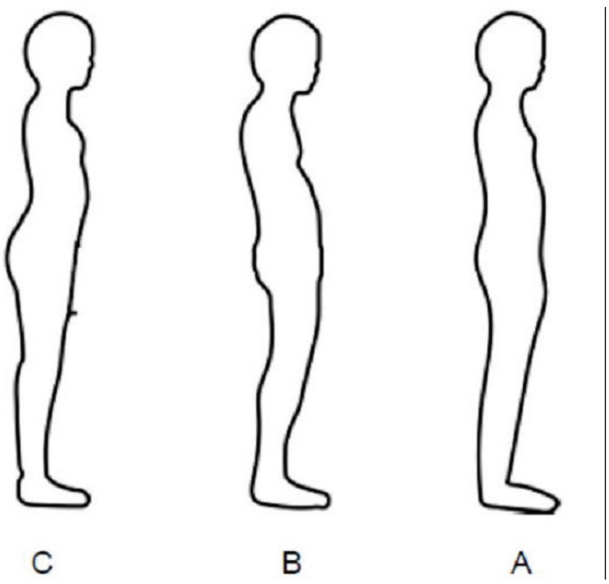

Fig. 2. Postural types: A) neutral, B) kyphosis, C) lordosis

The postural stability was assessed by means of the force plate Zebris FDM. The sampling frequency of the plate was 100 Hz. The total sway path and the total sway area were analyzed. The study was conducted in both groups, with eyes open and closed. The single test lasted 30 seconds.

Statistical analysis

The calculations were made using MedCac package v. 18.2.1., and distribution characteristics and descriptive measures were assessed for all variables. To evaluate the differences between the same variables in the sample and the control group, due to the normal distribution and homogeneous variations, Student's t-test for the independent samples was used to compare the sample and the control group, and paired samples t-test was used to compare the results of tests with eyes open and eyes closed in the same group. The analysis of differences between the values of stabilometric variables, depending on the type of posture and balance, was performed using the one-way analysis of variance ANOVA with the Student–Newman–Keuls post-hoc test. To evaluate the strength of relations between the studied variables characterizing the posture and its stability, the Pearson's linear correlation coefficient was used. The Chi-squared test was used to analyze the frequency of occurrence of the qualitative variables.

3. Results

The postural types analysis was performed based on the vertical line course showed that there are significant differences in the frequency of occurrence of postural types in the sample and the control group ($Chi^2 = 6 = 902$, $p = 0.0317$, Fig. 3).

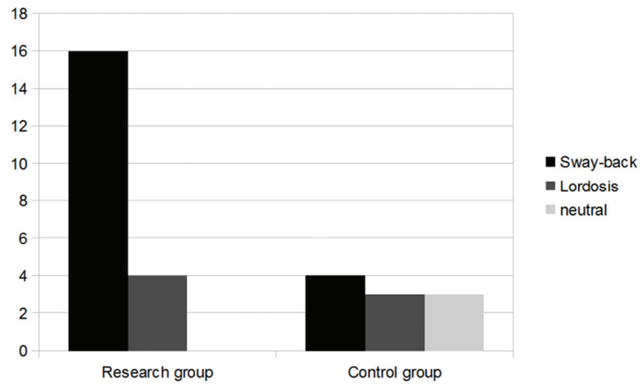

Fig. 3. Postural types in the studied groups

This variation was also observed when the sample was divided using Frohner Posture Index ($Chi^2 = 7.560$, $p = 0.02$, Fig. 4).

In the control group, there were only balanced postures, whereas in the sample, the dominating types were defective and bad postures with overly increased spine curvatures. The characteristics of the studied groups regarding the values of the Frohner Posture Index are presented in Table 2.

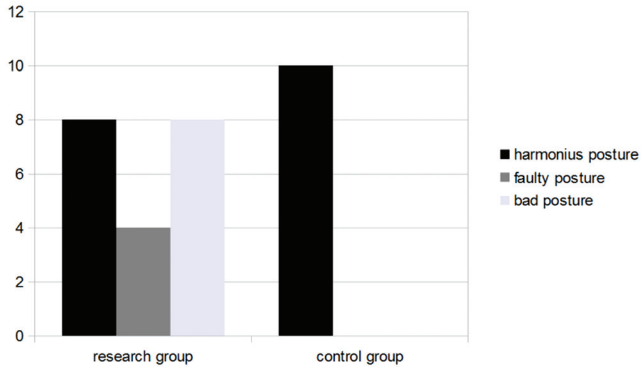

Fig. 4. Occurence of postural disorders in the studied groups

Table 2. Compilation of the arithmetic mean (*X*), standard deviation (SD), variation coefficient (V%) of the Frohner Posture Index in the studied groups

Variable	Sample $n = 20$			Control group $n = 10$		
	X	SD	V%	*X*	SD	V%
Frohner Posture Index	1.2	0.06	5.3%	1.4	0.25	17.7%

The analysis revealed that both groups showed high stability of the studied variable and small dispersion of individual results. This is confirmed by the values of standard deviations and variation coefficients. However, the Frohner Posture Index values in the group of volleyball players with ID were significantly higher than in the control group (t = 2.549, p = 0.00).

Table 3 presents the results of postural stability assessment in the studied groups, in tests with eyes open and closed.

The results in Table 3 show some differentiation of the obtained outcomes. For both, the sway path and Sway Area, there sample tended to obtain higher values of the studied variables than the control group. This refers to the results obtained from tests with both, eyes open and closed. We also noticed that the results of the sway path analysis are quite stable, whereas the results of the Sway Area analysis show significant individual differentiation and dispersion of the individual results. The comparisons between the tests with eyes open and closed show a significant differentiation of the individual results in both studied groups. A statistically relevant difference was observed only between the results of the sway path test in the sample group (Tab. 3). We should notice that there was the tendency to decrease the sway area of the stabilogram when eyes were closed. This applied to both, the sample and the control group. The changes, however, were not statistically significant.

The assessment of differences in the values of the studied variables, depending on the postural type identified according to the Frohner Posture Index, was carried out using the variance analysis and shows that the results vary. However, the statistically significant differences occur only for the sway path with eyes open (SPOE) (F-ratio = 4.171, p = 0.03). The post-hoc analysis revealed the significant difference between the harmonious and bad posture (Figs. 5, 6). Also, the diversity analysis of the stabilographic variables depending on the type of the body balance, showed some differentiation of the results. However, these differences were not statistically significant (Figs. 7, 8).

Table 3. Compilation of the arithmetic mean (*X*), standard deviation (SD), variation coefficient (V%) of differences in the sway path (SP) and sway area (SA) in the studied groups

Studied Variable	Sample $n = 20$			Control group $n = 10$			Student's t-test
	X	SD	V%	*X*	SD	V%	
SPOE [mm]	421	127.88	30.3	323	79.83	24.7	t = 1.875 p = 0.07
SPCE [mm]	470	124.58	26.5	402	116.53	28.9	t = –1.265 p = 0.22
t = 3.189, p = 0.01*				t = 1.950, p= 0.09			
SAOE [mm^2]	306	155.31	50.8	209	182.65	87.3	t = –1.376 p = 0.18
SACE [mm^2]	279	171.37	61.4	169	91.41	54	t = –1.604 p = 0.12
t = –0.888, p = 0.39				t = –0.445, – = 0.67			

* statistically significant differences.
SPOE – the total sway path with eyes open, SPCE – the total sway path with eyes closed.
SAOE – the sway area with eyes open, SACE – the sway area with eyes closed.

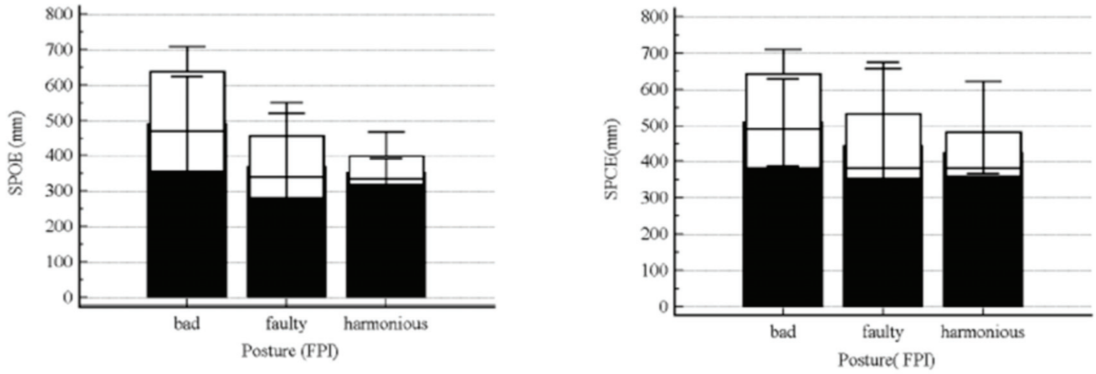

Fig. 5. Differentiation of the sway path, depending on the Frohner Posture Index – eyes open (SPOE), closed (SPCE)

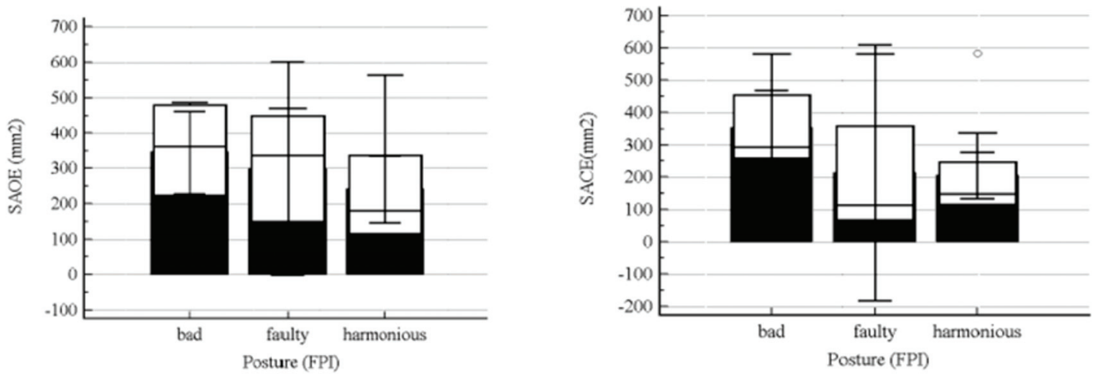

Fig. 6. Differentiation of the sway area, depending on the Frohner Posture Index – eyes open (SAOE), eyes closed (SACE)

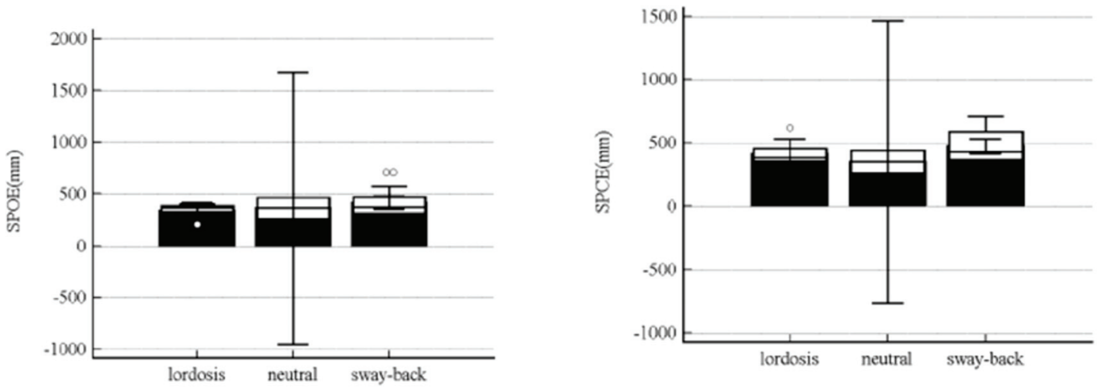

Fig. 7. Differentiation of the sway path depending on the balance type – eyes open (SPOE) – eyes closed (SPCE)

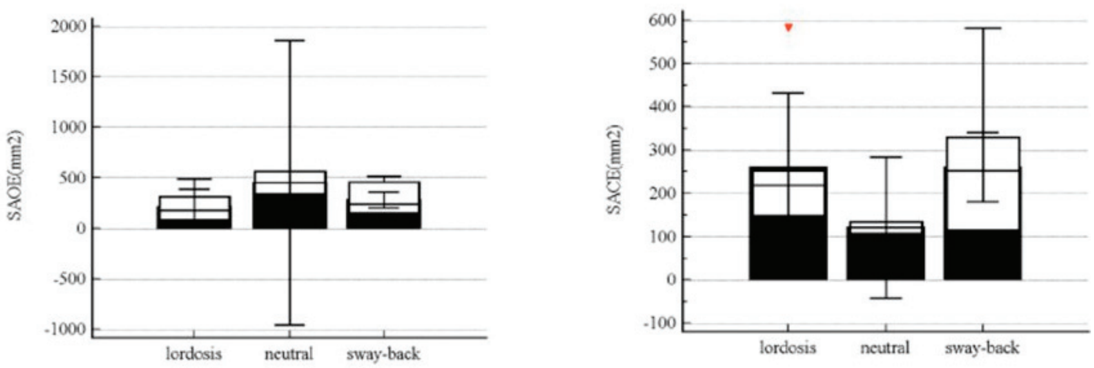

Fig. 8. Differentiation of the sway area, depending on the balance type – eyes open (SAOE), eyes closed (SACE)

Table 4. Evaluation of the strength of the relation between the Frohner Posture Index and stabilographic variables

Variable	SPOE [mm]	SPCE [mm]	SAOE [mm^2]	SACE [mm^2]
Posture Index	$r = 0.567$	$r = 0.372$	$r = 0.332$	$r = 0.493$

The assessment of the linear dependence of the Pearson's correlation coefficient between the Frohner Posture Index value and the stabilometric variables showed such relation at a level average for the sway path with eyes open (SPOE) and for the sway area with eyes closed (SACE). As for the other variables, the relation was poor (Table 4).

4. Discussion

The results of the studies conducted by other authors indicate that properly administered physical activity contributes to the increase in strength and improved balance in people with ID [7], [20], [21]. Compared to non-active control groups, it can also be a factor reducing the risk of cardio-vascular diseases [14]. However, the relation between the obtained results and the declared level of physical activity is ambiguous [10]. The analysis of the results obtained from the original studies focused on two issues. The first one referred to postural disorders. The literature research revealed that this topic was insufficiently exposed in reference to people with ID. The available publications point out to the frequency of defective postures in people with ID [6]. In the presented study, defective and bad postures according to the Frohner classification (IP) prevailed in the sample group. In the control group, there were only harmonious postures [17]. The Dolphens analysis of postural types yielded similar results [11]. There were no individuals with the neutral posture in the group with ID. The dominating postures were sway-backs observed in 16 out of 20 people. This situation may be explained by the fact that young people with ID have a limited ability to use somatosensory information and adjust their muscular responses to the repeating external perturbations [3]. According to Ting [23], during the sensory integration process the central nervous system uses these information to recognize the present body posture and generate muscular responses if it notices a deviation. The results indicate that people with ID have limited ability to actively maintain their posture and tend to keep certain body segments passive in the space. This may result in future overload lesions and pain in the spine [12]. The analysis of muscular activity for the sway-back posture shows that the activity of the rectus abdominis muscle increases and, at the same time, the activity of iliolumbar muscle decreases. In general, this postural type leads to a decrease in activity of the skeletal muscles, thus loads the skeleton, leading to the increased paraspinal muscular tension in the lumbar area. At the same time, the gluteus muscular tension decreases causing reduced pressure on the sacroiliac joint, what may lead to the destabilization of the pelvis [25]. The second studied issue referred to the assessment of postural stability in people with ID. The subject matter literature often points out to mobility restrictions and postural stability disorders in people with ID [5]. Dynamic regulation of the sensorimotor integration within the postural control takes place mainly by means of mechanical-receptive information (pressure receptors in the skin) and vestibular and ocular information systems [23]. One of the causes of the disturbed motor control in people with ID may be partially functioning vestibulo-ocular response (VOR) [26]. However, the assessment of the balance of the volleyball players with intellectual disability did not show clearly worse results for the individuals with ID than in the control group. The players with ID received higher sway path and sway area values, both with eyes open and closed, but these differences were not statistically significant. The only statistically significant difference was found between the SP results with eyes open and closed in the sample. The possible explaination is that inablity to see generates higher mechanical pressure on the forefoot, increasing the level of activity of the muscles in the lower limbs joints and stimulating more information from the mechanical receptors and, in consequence, increasing the musculoskeletal stiffness [8]. The study revealed some linear correlations between the parameters which determine the postural stability and postural quality measured with the Frohner Posture Index. This is not in line with previous reports by Ludwig who did not find such correlations in his studies among children and youth [20].

5. Conclusions

Due to the frequent occurrence of abnormal postural patterns in people with intellectual disability, overload changes can develop in the motor system, and consequently pain can occur. Postural defects for people with intellectual disabilities should be taken into account specifically, for example, the expanding and popularizing the "Special Olympics" program. Although perhaps without statistical significance, the results indicate differences in mean values of stabilographic parameters. It should be considered that both groups were relatively small and so it will be necessary to realise larger group sizes in future research. We are aware of weakness in the reduced data, yet we did notice a tendency, and this is the basis for the extension of experimentation. Additionally, it should be taken into account that the ID group was a group of active athletes.

The second issue is the role of valid physical activity in people with ID for improving systems for maintaining postural stability. Research has shown that there is a high level of efficiency of balance control mechanisms, both in healthy people and those with intellectual disabilities. This may indicate the important role of physical activity in stimulating the control mechanisms of balance and reducing the risk of falls and injuries in future. From the obtained research results, an important element is the unclear relationship between the quality of posture and the ability to maintain posture stability. There were no correlations detected between body posture and stabilographic parameters in the studies. It can be supposed that the mechanisms of maintaining balance do not depend soley upon the type of posture, but it is a multidimensional variable. It is very likely that the ability to maintain balance depends to some extent on body posture. In addition, all subjects are people with increased physical activity resulting from this discipline being applied. It could be assumed that greater physical activity could improve the ability to maintain balance. Undoubtedly, the search for correlations between body posture and the ability to maintain balance should be another direction of research, not only for the group of people with intellectual disabilities, but also for the healthy population.

The possibility of an unambiguous response to these relations, however, requires research with developed materials and the use of more variables characterizing postural aspects of the body. The same can be said for determining the critical stiffness values of the system depending on the differences in the quality of body posture.

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