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Canonical Correlations Between Body Posture Variables and Postural Stability in Children with Scoliosis and Scoliotic Posture

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Abstract

Background: The aim of the study was to analyse the correlation between body posture variables and postural stability in children with scoliosis and scoliotic posture.

Methods: Spinal examination photogrammetry used the photometric Moiré method. Based on the angle size of the of spinal curvature, scoliotic posture was determined: 1-9°, and scoliosis: ≥10°. Postural reactions were tested using the Tecnobody ST 310 Plus Stability System platform. Children attended therapy at the Inter-school Centre of Corrective and Compensatory Gymnastics in Starachowice The study was conducted in June 2011. There were 21 children with scoliotic posture (7%) and 7 with scoliosis (25%).

Results: In the canonical analysis of body posture variables, the highest share comprised of: trunk inclination angle, alpha angle, chest kyphosis angle, length of lumbar lordosis, length of lumbar lordosis/total spine length, shoulder asymmetry – right higher, shoulder asymmetry – left higher, absolute of pelvis tilt angle, coefficient of shoulder asymmetry relative to C_7, primary curvature angle, length of secondary curvature/total spine length, depth of secondary curvature/total spine length.

Significance: High values of canonical correlation coefficients, despite lack of significance, indicate the possibility of strong a correlation between body postural variables and postural stability that can be demonstrated with a greater sample size.

Keywords: scoliotic posture, idiopathic scoliosis, postural stability, posturography computer

1. Introduction

Children with scoliosis compensate for incorrect alignment of individual body parts which allows them to maintain balance [1,2]. Postural stability plays an important here [3,4]. Stabilization is considered in the biomechanical aspect, but also in part of CNS movement control [5,6]. For a long time, it was thought that the superficial muscles of the trunk were responsible for stabilization of the body [7,8]. A modern approach to the problem of active stabilization of the spine originates in Bergmark's ideas [9]. Stabilization of the body is associated with postural reactions which are its resultant and are part of balance [10,11]. An overall assessment of postural stability is provided via posturographic testing [12,13]. This is possible through the analysis of reactions and postural strategies that form the basis of systems maintaining the body balance [14]. Equilibrium is a specific state of the postural system that characterizes the vertical orientation of the body achieved by aligning the forces acting on the body and their moments [15]. Balance provides the nervous system with reflex antigravity muscles [16]. There are ways to build or correct this stabilization by normalizing postural tension and thus, scoliosis re-education [17]. The aim of the study was to analyse the correlation between body posture variables and postural stability in children with scoliosis and scoliotic posture.

2. Methods

2.1 The Population

The study included 28 girls, aged 7-18 with scoliotic posture and idiopathic scoliosis. The selection of test subjects was not random. Children attended therapy at the Inter-school Centre of Corrective and Compensatory Gymnastics school. The study was conducted in June 2011.

2.2 Information Collection

All procedures performed in test involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The guardians of the children were informed about the purpose of the study and expressed written consent for their children's participation in the study. The study was non-invasive and free of charge. The patients willingly participated in the study, and perceived it as a concern about their state of health.

2.3 Measurement Scales

The photogrammetric Moiré method was used in postural tests. Spinous processes from C7 to S1 were marked on the back of tested subject using a marker, as well as the acromion, lower angles of the shoulder blades and the posterior superior iliac spine. The subject assumed a habitual position at the rear of the device at a distance of 3.2 m. Stripes were projected onto the back, and the focusing of the lens allowed the Moiré image to be obtained. The image of the spine was received by an optical system with a camera, then it was passed onto to the analogue monitor and finally, to the computer. In this way, a three-dimensional image of the back was formed. The following parameters of the posture in the sagittal plane were analysed: total spine length (MM), trunk inclination angle (°), absolute trunk inclination angle (°), alpha angle (°), beta angle (°), gamma angle (°), length of chest kyphosis (MM), length of chest kyphosis/total spine length (%), angle of chest kyphosis (°), actual angle of chest kyphosis (°), actual angle of chest kyphosis/total spine length (%), depth of chest kyphosis (mm), depth of chest kyphosis/total spine length (%), absolute value of chest kyphosis depth/total spine length (%), length of lumbar lordosis (mm), length of lumbar lordosis/total spine length (%), lumbar lordosis angle (°), actual angle of lumbar lordosis (°), actual angle of lumbar lordosis/total spine length (%), depth of lumbar lordosis (mm), depth of lumbar lordosis/total spine length (%). Next, primary and secondary spinal curvature parameters were analysed: shoulder asymmetry – right higher (mm), shoulder asymmetry - left higher (mm), shoulder line angle (°), shoulder blade asymmetry – right higher (mm), shoulder blade asymmetry – left higher (mm), pelvis tilt angle (°), absolute value of pelvis tilt angle (°), pelvis rotation angle (°), pelvis rotation (°), shoulder/pelvis asymmetry coefficient (%), shoulder asymmetry coefficient - KK point (%), shoulder/C_7 asymmetry coefficient (%), length of curvature (mm), length of curvature/total spine length (%), depth of curvature (mm), depth of curvature/total spine length (%), curvature angle (°), absolute value of curvature angle (°). Based on the size of the spinal curvature, the following were distinguished: scoliotic postures: 1-9° and scoliosis: ≥10°. Postural stability was tested using the static-dynamic ST 310 Plus Stability System platform made by Tecnobody. Testing on the platform consisted of continuous monitoring of the center-of-foot pressure (COP). By recording the postural sways as a function of time, accurate information about the postural system was obtained. The standard free-standing stability test (the Romberg test) was performed. The trial consisted of two successive 30-second tests: the first with open eyes (OE - open eyes) and the second with closed eyes (CE - closed eyes). The studied subject assumed a habitual position with arms lowered along the torso and the head straightened. The test begun when the subject assumed the position, and the center-of-pressure (COP) was displayed on the screen. The following parameters were recorded for the measurement of COP: average COP X in relation to the platform axis determines lateral X coordinates (mm); average COP Y in relation to the platform axis determines frontal-posterior Y coordinates (mm); medium-lateral standard deviation X is the mean oscillation along the X axis (mm) and the mean lateral deflection (mm), i.e. the average distance between the extreme deflection from the COP in the lateral plane, forward-backward standard deviation Y is the mean oscillation along the Y axis (mm) and the mean forward-backward deflection (mm) - the average distance between the extreme deflection from the COP in the sagittal plane, average forward-backward speed Y, i.e. the mean speed of oscillation along the Y axis (mm/s). It is the quotient of the length of deflection from the COP during the test which indirectly informs about the dynamics of the postural stability regulation process in a standing position, average medium-lateral speed X, i.e. the mean speed of oscillation along the X axis (mm/s). It is the quotient of the length of deflection from the COP during the test which indirectly informs about the dynamics of the postural stability regulation process in a standing position, perimeter. This is the total length of the COP path in both planes during oscillation (mm), ellipse area. This is the total area the COP drew in both planes during oscillation (mm^2), perimeter ratio is the ration of the perimeter with open (OE) and closed (CE) eyes in the Romberg test, area ratio is the ratio of the ellipse area with eyes closed (OE) to the area with open eyes (OE) in the Romberg test. Individuals with postural disorders generally show higher values for all the listed parameters. Similarly, higher levels of sways occur in children. Variables were verified for normal distribution using the Shapiro-Wilk test. In order to distinguish variables without correlations, factor analysis was conducted. The correlation between scoliotic and postural stability variables was defined by canonical correlations. Significant levels were at $p<0.05$.

3. Results

There were 21 children with scoliotic posture (7%) and 7 with scoliosis (25%). In order to reduce the large number of random variables, canonical correlation analysis was preceded by factorial analysis. This analysis was also performed to determine the structure of the correlation between the tested variables. In this way, the observed variable (R) factors (F), which are linear combinations of these variables, are replaced.

3.1 Descriptive Analysis

The factorial loads for particular variables determine the extent to which the factor represents a given variable. It is assumed that the variables for which the absolute values of the factor loadings are greater than 0.7, are significant for the factor. The factor for these variables is representative and the set of variables can be replaced by it. It was assumed that only variables associated with large values of factor loads carry the right amount of information, i.e. they have a large amount of variability, and these variables should be considered in further analysis of the correlation. Only factors that accounted for the largest variance were considered. The criterion was used to select those factors whose share in total variance was significantly higher than the others. The measure of the share of a factor in the total variance was its eigenvalue. Using the scree plot to determine their number was one of the methods for selecting factors. Factors of high volumetric variables were also taken into account in their selection. The factorial array was used in further analysis in place of the values of the variables directly observed. In this way, the determinants were used in multiple regression analysis, both as dependent and independent variables. The following five factors characterizing body posture in the sagittal plane were distinguished: Factor 1: angle of chest kyphosis (LC=-0.882), Factor 2: trunk inclination angle (LC=-0.944), Factor 3: alpha angle (LC=0.919), Factor 4: length of lumbar lordosis (LC=0.960), Factor 5: actual angle of lumbar lordosis/total spine length (LC=-0.847). The share of these five factors in the total variance was significantly higher than the others. Selected orthogonal factors accounted for 89.3% of the total variance (Table 1). Then, from among the normalized scoliotic variables, the following seven factors were identified: Factor 1: length of secondary curvature /total spine length (LC=0.973), Factor 2: primary curvature angle (LC= =-0.933), Factor 3: depth of primary curvature/total spine length (LC=0.967), Factor 4: coefficient of shoulder asymmetry relative to C_7 (LC=0.867), Factor 5: absolute value of pelvis tilt angle (°) (LC=0.797), Factor 6: shoulder blade asymmetry – left higher (mm) (LC=0.786), Factor 7: shoulder asymmetry – right higher (LC=0.834). The emerged orthogonal factors accounted for 86.3% of the total variance (Table 2). Similarly, five factors of postural stability with open eyes were identified: Factor 1: medium-lateral standard Deviation X (OE) (LC=0.961), Factor 2: absolute average of COP X (OE) (LC=-0.933), Factor 3: forward-backward standard deviation Y (OE) (LC=0.883), Factor 4: average forward-backward speed Y (OE) (LC=0.817), Factor 5: average COP X (OE) (LC=-0.829). The factors accounted for 92.6% of the total variance (Table III). Then, among the normalized variables of postural stability with closed eyes (CE), five factors were identified: Factor 1: Factor 1: medium-lateral standard deviation X (OE) (LC=0.961), Factor 2: absolute value of average COP X (OE) (LC=-0.886), Factor 3: forward-backward standard deviation Y (OE) (LC=0.883), Factor 4: average forward-backward speed Y (OE) (LC=0.817), Factor 5: average COP X (OE) (LC=-0.829). The factors accounted for 92.6% of the total variance (Tab. 3). Then, among the normalized variables of postural stability with closed eyes (CE), five factors were identified: Factor 1: average forward-backward speed Y (CE) (LC=0.974), Factor 2: absolute value of average COP Y (CE) (LC=0.927), Factor 3: absolute value of average COP X (CE) (LC=-0.902), Factor 4: average COP X (CE) (LC=0.937), Factor 5: medium-lateral standard deviation X (CE) (LC=0.515). The extracted orthogonal factors accounted for 89.9% of the total variance (Table III). In the canonical correlation related to body posture variables, the largest share comprised of: trunk inclination angle OE (0.555), CE (0.243), alpha angle OE (-0.070), CE (-0.422), chest kyphosis angle OE (0.216), CE (-0.347), length of lumbar lordosis OE (0.409), CE (0.107), length of lumbar lordosis/total spine length OE (-0.339), CE (0.864), shoulder asymmetry – right higher OE (-0.199), CE (-0.271), shoulder asymmetry – left higher OE (-0.641), CE (0.392), absolute of pelvis tilt angle OE (-0.621), CE (0.289), coefficient of shoulder asymmetry relative to C_7 OE (0.114), CE (0.142), primary curvature angle OE (-0.266), CE (0.150), length of secondary curvature/total spine length OE (0.846), CE (0.241), depth of secondary curvature/total spine length OE (0.988), CE (-0.237) (Tab. 4). In the canonical correlation regarding postural stability variables, the largest share regarded: average COP X OE (-0.088), CE (0.054), absolute value of average COP X - OE (-0.793), CE (0.251), forward-backward standard deviation Y

- OE (-0.590), medium-lateral standard deviation X OE (0.333), average forward-backward speed Y - OE (0.038), CE (-0.364), absolute value of average COP Y (CE) (0.577), average medium-lateral speed X CE (0.028), perimeter ratio (OE) (-0.684), CE (0.971), area ratio (OE) (0.569), CE (-0.524), (Table 4). The high value of the canonical correlation coefficient, despite lack of significance (R=0.95521) (*p*=0.22960) (OE) and (R=0.95521), (*p*=0.27144) (CE) indicates the possibility of a strong correlation between both sets of variables that would be able to be demonstrated with a larger sample size (Table 4).

Table 1. Factorial analysis of body posture variables

(factorial loads – LC)

Body posture variables	**Factor 1**	**Factor 2**	**Factor 3**	**Factor 4**	**Factor 5**
Trunk inclination angle	-0.170	**-0.944**	0.061	-0.019	0.101
Abs value of trunk inclination angle	-0.135	-0.926	0.035	0.061	0.111
Alpha angle	-0.168	-0.173	**0.919**	0.001	-0.043
Beta angle	0.724	0.514	0.105	-0.042	0.040
Gamma angle	0.557	-0.698	0.053	0.191	0.303
Delta angle	0.599	-0.271	0.712	-0.005	0.220
Compensation index	0.526	-0.393	-0.604	0.154	0.261
Absolute value of compensation index	-0.409	0.120	0.481	-0.021	-0.289
Length of chest kyphosis	0.108	-0.079	-0.156	0.840	0.493
Length of chest kyphosis / Total spine length	-0.046	-0.002	0.053	0.049	0.809
Angle of chest kyphosis	**-0.882**	0.210	-0.195	-0.032	-0.286
Actual angle of chest kyphosis	0.384	-0.159	-0.125	0.458	0.730
Actual angle of chest kyphosis / Total spine length	0.445	-0.167	-0.027	-0.088	0.838
Depth of chest kyphosis	0.874	0.296	-0.086	0.036	0.270
Depth of chest kyphosis / Total spine length	0.866	0.322	-0.066	-0.154	0.254
Absolute depth of chest kyphosis / Total spine length	0.846	0.365	0.019	-0.129	0.197
Length of lumbar lordosis	-0.075	0.005	0.045	**0.960**	-0.144
Length of lumbar lordosis / Total spine length	-0.348	0.185	0.432	0.252	-0.681
Angle of lumbar lordosis	-0.318	-0.240	-0.886	0.150	-0.027
Actual angle of lumbar lordosis	-0.300	0.055	-0.092	0.734	-0.577
Actual angle of lumbar lordosis / Total spine length	-0.434	0.141	0.059	0.128	**-0.847**
Depth of lumbar lordosis	0.324	0.675	0.504	0.229	-0.043
Depth of lumbar lordosis / Total spine length	0.263	0.696	0.562	0.013	-0.133
Baseline value	5.760	4.256	3.615	2.650	4.261
Share	0.250	0.185	0.157	0.115	0.185
Total share of values	0.250	0.435	0.593	0.708	**0.893**

Table 2. Factorial analysis of scoliotic variables

(factorial loads – LC)

Scoliotic variables with open eyes	**Factor 1**	**Factor 2**	**Factor 3**	**Factor 4**	**Factor 5**	**Factor 6**	**Factor 7**
Shoulder asymmetry – right higher	0.225	0.286	0.169	0.025	-0.035	-0.106	**0.834**
Shoulder asymmetry- left higher	0.071	-0.305	0.096	-0.064	0.456	0.618	-0.429
Shoulder line angle	0.0	-	0.00	0.06	0.164	0.327	-

	75	0.406	2	2			0.733
Absolute shoulder line angle	0.335	-0.211	0.263	0.098	0.661	0.428	0.119
Shoulder blade asymmetry – right higher	0.096	0.034	0.206	0.072	0.020	-0.778	-0.053
Shoulder blade asymmetry – left higher	0.196	0.139	0.058	0.257	0.015	**0.786**	-0.061
Pelvis tilt angle	0.026	0.110	-0.080	-0.265	0.785	0.008	-0.169
Absolute pelvis tilt angle	-0.266	-0.149	0.076	0.110	**0.797**	-0.060	-0.108
Pelvis rotation angle	0.015	-0.299	0.291	-0.726	-0.111	-0.266	-0.177
Absolute pelvis rotation angle	0.061	-0.171	0.267	-0.010	-0.148	0.389	0.682
Coefficient of shoulder asymmetry – KK	-0.092	-0.164	-0.083	0.634	0.110	0.493	-0.382
Coefficient of shoulder asymmetry relative to C_7	0.091	-0.197	-0.042	**0.867**	-0.234	-0.134	-0.022
Length of primary curvature	-0.882	0.012	0.133	-0.092	0.038	-0.034	0.041
Length of primary curvature / Total spine length	-0.971	-0.060	0.113	0.035	-0.044	0.016	0.033
Depth of primary curvature	-0.119	0.086	0.960	-0.100	0.040	-0.064	0.085
Depth of primary curvature / Total spine length	-0.106	0.065	**0.967**	-0.072	0.034	-0.074	0.071
Primary curvature angle	-0.036	**-0.933**	-0.093	0.029	0.032	0.064	-0.136
Absolute secondary curvature angle	0.167	-0.007	0.960	-0.077	0.059	0.006	0.126
Length of primary curvature	0.933	0.068	-0.115	-0.088	0.040	-0.032	-0.003
Length of secondary curvature / Total spine length	**0.973**	0.046	-0.124	-0.034	0.034	-0.002	-0.035
Depth of secondary curvature	0.802	0.079	0.341	0.109	-0.124	0.106	0.275
Depth of secondary curvature / Total spine length	0.8	0.0	0.32	0.12	-0.129	0.112	0.24

	12	65	8	5			0
Secondary curvature angle	0.266	0.902	0.081	-0.049	-0.096	0.044	0.173
Absolute secondary curvature angle	0.725	0.239	0.539	-0.062	-0.046	0.064	0.137
Baseline value	5.808	2.396	3.699	1.928	2.083	2.439	2.352
Share	0.242	0.100	0.154	0.080	0.087	0.102	0.098
Total share value	0.242	0.342	0.496	0.576	0.663	0.765	**0.863**

Table 3. Factorial analysis of postural stability variables with open and closed eyes (OE/CE)

Variables of postural stability with open eyes (OE)	**Factor 1**	**Factor 2**	**Factor 3**	**Factor 4**	**Factor 5**
Average COP X	-0.203	-0.126	0.002	0.338	**-0.829**
Absolute value of average COP X	-0.021	**0.886**	-0.183	0.247	0.203
Average COP Y	-0.160	0.399	-0.154	0.063	0.822
Absolute value of average COP Y	-0.083	0.882	0.074	-0.280	0.225
Forward-backward standard deviation Y	0.197	-0.106	**0.883**	0.341	-0.113
Medium-lateral standard deviation X	**0.961**	0.029	0.130	0.031	0.031
Average forward-backward speed Y	0.274	0.030	0.379	**0.817**	-0.200
Average medium-lateral speed X	0.894	-0.188	-0.049	0.304	0.013
Perimeter ratio	0.57	-	0.269	0.	-

	8	0.039		736	0.142
Ellipse area	0.809	-0.010	0.462	0.282	0.028
Baseline value	2.899	1.787	1.292	1.757	1.530
Share	0.290	0.179	0.129	0.176	0.153
Totalled share of values	0.290	0.469	0.598	0.773	**0.926**
Variables of postural stability with open eyes (CE)	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Average COP X	0.095	0.083	0.123	**0.937**	0.044
Absolute value of average COP X	-0.053	-0.109	**-0.902**	-0.115	0.015
Average COP Y	-0.146	0.821	0.306	-0.026	0.308
Absolute value of average COP Y	0.100	**0.927**	-0.090	0.144	-0.146
Forward-backward standard deviation Y	0.891	0.034	-0.170	0.182	0.221
Medium-lateral standard deviation X	0.496	0.164	-0.393	0.380	**0.515**
Average forward-backward speed Y	**0.974**	-0.047	0.111	0.022	0.053
Average medium-lateral speed X	0.521	0.003	0.059	-0.	0.773

				007	
Perimeter ratio	0.905	-0.051	0.133	0.006	0.342
Ellipse area	0.671	0.142	-0.276	0.340	0.485
Baseline value	3.573	1.605	1.224	1.206	1.385
Share	0.357	0.160	0.122	0.121	0.139
Totalled share of values	0.357	0.518	0.640	0.761	**0.899**

Table 4. Summary of canonical analysis

Left set			**Right set**	
Number of variables	**12**	**Canonical weights**	**7**	**Canonical weights**
Isolated variation	66.04%		100.00%	
Total redundancy	31.54%		46.73%	
Variables	Body posture and scoliotic variables (OE)		Variables of postural stability with open eyes	
1	Trunk inclination angle	0.555	Average COP X	-0.088
2	Alpha angle	-0.070	Absolute value of Average COP X	-0.793
3	Chest kyphosis angle	0.216	Forward-Backward Standard Deviation Y	-0.590
4	Length of lumbar lordosis	0.409	Medium-Lateral Standard Deviation X	0.333
5	Length of lumbar lordosis /Total spine length	-0.339	Average Forward-Backward Speed Y	0.038
6	Shoulder asymmetry – right higher	-0.199	Perimeter ratio	-0.684
7	Shoulder blade asymmetry – left higher	-0.641	Area ratio	0.569
8	Absolute of pelvis tilt angle	-0.621		
9	Coefficient of shoulder asymmetry relative to C_7	0.114		
10	Primary curvature angle	-0.266		
11	Length of secondary curvature /Total spine length	-0.846		
12	Depth of secondary curvature	0.988		

	/Total spine length			

R = 0.92214; Chi^2 (84) = 93.268; p=0.22960

Number of variables	**12**	Canonical weights	**7**	Canonical weights
Isolated variation	61.67%		100.00%	
Total redundancy	28.80%		39.27%	
Variables	Body posture and scoliotic variables (CE)		Variables of postural stability with closed eyes	
1	Trunk inclination angle	0.243	Average COP X	0.054
2	Alpha angle	-0.422	Absolute value of Average COP X	0.251
3	Chest kyphosis angle	-0.347	Absolute value of Average COP Y	0.577
4	Length of lumbar lordosis	0.107	Average Forward-Backward Speed Y	-0.364
5	Length of lumbar lordosis / Total spine length	0.864	Average Medium-Lateral Speed X	0.028
6	Shoulder asymmetry – right higher	-0.271	Perimeter Ratio	0.971
7	Shoulder blade asymmetry – left higher	0.392	Area Ratio	-0.524
8	Absolute of pelvis tilt angle	0.289		
9	Coefficient of shoulder asymmetry relative to C_7	0.142		
10	Primary curvature angle	0.150		
11	Length of secondary curvature / Total spine length	0.241		
12	Depth of secondary curvature /Total spine length	-0.237		

R = 0.95521; Chi^2 (84) = 91.446; p=0.27144

4. Discussion

Many studies have shown that people with scoliotic changes are characterized by worse postural stability compared to healthy individuals [18,19]. In other studies evaluating body posture and balancing responses, there were no differences between individuals with idiopathic scoliosis and the control group in the assessment of static balance. On the other hand, considerable divergences in the assessment of dynamic balance have been observed, indicating that dynamic proprioception is related to body posture [20]. Other researchers assessed postural control with open and closed eyes on the Kistler Power Platform in idiopathic scoliosis and among healthy individuals. They demonstrated a weaker ability to maintain balance in people with scoliosis compared to healthy individuals. According to other authors, a complex system that regulates balancing and postural reactions as well as arbitrary movements in idiopathic scoliosis may be disturbed [21]. Other studies have examined the impact of weight training on improving static and dynamic balance in children with developmental coordination disorders. The study involved children aged 7 to 9. It has been shown that strength training significantly increased muscle strength in children with coordination disorders and improved their stability but did not significantly affect their dynamic balance [22]. In turn, other researchers assessed the relationship between body posture and static balance among children with sensory-motor deficits. Balance was evaluated with the BTS P-6000 platform on a stable surface, with open and closed eyes. The Nikon D-5000 digital camera was used to evaluate body posture, which displayed images of body posture in the frontal and sagittal planes. Results showed that children with cerebral palsy had the highest number of abnormalities both in the sagittal and frontal planes compared to the other groups. In case of analysis of equivalent reactions in the sagittal plane, the greatest instability in the open and closed eyes test was observed in children with mild mental retardation, and with closed eyes, in the case of visual impairment. In the frontal plane, the greatest problems maintaining balance occurred in individuals with cerebral palsy and mild mental retardation. The best results were obtained by persons with hearing impairments [23]. The main clinical problem of children with scoliotic changes is postural hypothyroidism, disturbing the development of central stabilization in the body [24]. Re-education of the postural system, which is the primary goal of scoliosis therapy, is basically developing the possibility of body stabilization [25]. The correct central stabilization in each plane is the so-called postural equalization [26]. Postural alignment is the correct alignment of individual parts of the body in static and moving positions occurring in all planes [27]. Postural alignment in the frontal plane is the symmetry of the individual right and left segments of the body, which is accompanied by the axial alignment of the knees [28]. In the transverse plane, the expression of postural alignment is balance in rotational movement tension of the trunk and the intermediate positioning of the lower limbs in the hip joints between external and internal rotation [29]. Scoliosis is just a symptom, an external manifestation of unrecognized pathology [30]. More and more followers have a multifactorial concept including genetically conditioned CNS changes that cause dysfunctions in the postural system [31]. From a neuronal developmental point of view, primary scoliosis is a central disorder of postural tension, and only afterwards are there consequences of biomechanical compensation [32]. In our opinion, scoliosis is a disorder associated with dysfunction of the body caused by improper CNS functioning [33]. This dysfunction reduces the tension of postural muscles and disrupts the stabilization of the body. These changes are primary and preceded by external symptoms of scoliosis.

5. Conclusions

In the canonical analysis of body posture variables, the highest share comprised of: trunk inclination angle, alpha angle, chest kyphosis angle, length of lumbar lordosis, length of lumbar lordosis/total spine length, shoulder asymmetry – right higher, shoulder asymmetry – left higher, absolute of pelvis tilt angle, coefficient of shoulder asymmetry relative to C_7, primary curvature angle, length of secondary curvature/total spine length, depth of secondary curvature/total spine length. In the canonical analysis of postural stability variables, the largest share consisted of: average COP X (OE, CE), absolute value of average COP X (OE, CE), forward-backward standard deviation Y (OE), medium-lateral standard deviation X (OE), average forward-backward speed Y (OE, CE), absolute value of average COP Y (CE), average medium-lateral speed X (CE), perimeter ratio (OE, CE), area ratio (OE, CE). High values of canonical correlation coefficients, despite lack of significance, indicate the possibility of strong a correlation between body postural variables and postural stability that can be demonstrated with a greater sample size.

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