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The differences in postural reactions between scoliosis and scoliotic posture

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SUMMARY

The aim of the research was to demonstrate the differences in amplitudes of postural reactions in girls with scoliotic posture and idiopathic scoliosis. 28 girls aged 7-18 years old were involved in the study. Children attended to the Interschool Centre of Corrective Exercises in Starachowice. The research was conducted in June 2011. Spine research was made by Exhibeon digital radiography. Based on the size of the angle of spinal curvature there were identified: scoliotic posture: 1-9° and scoliosis: ≥10°. Postural reactions were examined by static-dynamic Tecnobody's ST 310 Plus Stability System platform. There were 21 (75%) children with scoliotic posture, and 7 (25%) with idiopathic scoliosis. Student's t-test showed a significantly higher postural reactions for scoliosis in relation to scoliotic postures in case of: Average Forward-Backward Speed (OE), (p=0,05), Medium-Lateral Standard Deviation X (CE), (p=0,002), and Ellipse area (CE), (p=0,012). To verify the significant differences, demonstrating the lack of homogeneity of variance, the Mann–Whitney U-test has been used, which showed a significant differences between the scoliotic posture and scoliosis in case of: Medium-Lateral Standard Deviation X (CE), (p=0,0012), Average Forward-Backward Speed (OE), (p=0,0548), and Ellipse area (CE) (p=0,0047). Together with an increase of the angle of curvature, the value of these postural reactions also grew. Most of postural reactions didn't fit the norm.

Key words: postural reactions, scoliotic posture, scoliosis.

INTRODUCTION

According to the guidelines of Society on Scoliosis Orthopaedic and Rehabilitation Treatment (SOSORT), we can speak about scoliosis only when the Cobb angle will reach at least 10°. Curvatures with a smaller angular value are called the scoliotic posture [1-4]. The main symptom of scoliosis is the lateral bending of the spine. The construction of the spine, with an off-axis connection of vertebrae, doesn't allow for its lateral flexion without the simultaneous rotation of the vertebral body. Scoliosis is also accompanied by changes in the sagittal plane, most often in the form of a shallowed thoracic kyphosis. The size of scoliotic changes depends on the individual variable spontaneous compensation [1]. Forecasting in scoliosis is based on the observation and analysis of the natural history of this disease. If the lateral curvature of the spine with the Cobb angle of 10° and more, shows throughout the year the progression of 5° or more, then it is the progressive scoliosis. The biggest tendency to progression occurs in girls with right thoracic scoliosis and right thoracic and left lumbar scoliosis. The spine primarily acts as a support, and thereby influences on the spatial system of the whole body [1]. Posture is a way of keeping a person in a standing position, of which the outward manifestation is a spatial system of various body segments and its figure. Body posture, as a dynamic act, is an element of motor coordination [1-5]. The posture in a balance is maintained automatically, without consciousness. In a complex system, which is responsible for postural control and balance, there are two separated but interrelated structures. The first one is a gaze stabilization system, which consists of a direction control, and visual acuity during the activities connected with movements of head and whole body. The second is a postural stabilization system, which keeps the body in balance at rest and in motion. Both the gaze and postural stabilizing systems, differs in source of receptors information, reports about the motion reactions of a various parts of the body, and in involvement of a different pathways in the CNS. They are closely dependent on each other, because gaze stabilization isn't possible until the body and head with eyeballs aren't stable too. In turn, the correct vision, which depends on a stable gaze, is one of the primary senses that allows the control and stabilization of posture. These information from receptors must be integrated firstly, and then the appropriate postural reactions are triggered. These reactions are an integrated response, and many muscle groups are the subject of simultaneous control. Human, keeping a vertical posture while standing, strive to the state of equilibrium, but he never reach it [6-9]. It can be assumed that the postural control in a certain area is characterized by the non-asymptotic stability process (oscillatory). In the upright posture, projection of the center of gravity of the human body remains in a small, strictly defined feet support area. This area is about 5 cm anterior from the lateral ankles of talocrural joints. The center of gravity doesn't remain at one point, but performs small, random movements (deviations), with an amplitude of up to a dozen millimeters. Such postural reactions (fluctuations) can be recorded in posturographic studies as a displacements of the center of feet pressure (COP) on the ground. In posturography, the measure of postural stability is the distance of the center of pressure from the edge of the feet. In this case, it is assumed that the envelope of the feet which constitutes the border of a support surface, is also a border of stability. In fact, an area of stability is much smaller than the support surface, and its size also depends on the height and body weight, and on the efficiency of locomotor system. It is necessary to indicate a significant difference in interpretation of the center of feet pressure (COP) displacements on the ground from the deviations of the center of gravity (COG) of the body. COP and COG signals are compatible only under static conditions, when the COP is the projection of COG on a support surface. In fact, the COP signal of the person performing standing on both feet, moves of about 0,4 cm in sagittal plane and about 0,18 cm in frontal plane. COG deviations are slightly smaller. The differences in movements of COG and COP in the sagittal plane are related with the moments of forces, generated in the ankle joints. In turn, the smaller amplitude displacement of COG in the frontal plane, is the result of activity of adductor and abductor muscles in the hip. Postural sway are so small and fast that they don't threaten the stability of the body and do not reach the consciousness. They are invisible to the naked eye, but clear enough to stimulate the appropriate receptors, and trigger a response aiming to restore the correct system [11,12]. The aim of the research was to demonstrate the differences in amplitudes of postural reactions in girls with scoliotic posture and idiopathic scoliosis, during the Romberg's Test, on Tecnobody's ST 310 Plus Stability System platform.

MATERIAL AND METHODS

The study included 28 girls aged 7-18 years old with scoliotic posture and idiopathic scoliosis. All examined persons were selected intentionally. Children attended to the Interschool Centre of Corrective Exercises in Starachowice. The research was conducted in June 2011. Spine research was made by Exhibeon digital radiography. Pixel Technology's Exhibeon digital radiology is a valuable diagnostic tool, which replace a traditional X-ray film. Exhibeon runs on Linux and Microsoft Windows operating systems. With a browser, we can describe changes in bone structure, and soft tissues. Exhibeon currently supports 84 graphic image formats, compatible with DICOM, including animation formats presented in CINE mode. Exhibeon is able to cooperate simultaneously with multiple image archives - PACS servers. The program supports the format DICOMDIR, and allows to search the images inside catalog. It allows printing on DICOM printers, and their configuration, through the base device, is simple. Exhibeon digital radiology allows, among others, to outline the central sacral vertical line, visible on X-ray of the spine on the computer screen, measure of the angle of axial circle rotation and to determine the Cobb angle. Radiographs have been taken of a free-standing position, anterior-posterior projection and lateral. With a browser, we could describe changes in bone structure, and soft tissues. X-ray included lumbar, thoracic and cervical spine, chest, and pelvis with hip joints. The Cobb angle has been marked on X-ray of the spine, which is visible on the computer screen. For the study of postural sway, the computerized posturography has been used. These deviations were examined by static-dynamic Tecnobody's ST 310 Plus Stability System platform. The research based on continuous observation of the centre of feet pressure (COP). By recording the horizontal deflection of the body (postural sway) as a function of time, the detailed information concerning the postural system has been obtained. The COP displacements reflected the movements of center of body mass (COM) in the frontal and sagittal plane. The frequency of signal was 20 Hz. Change of the maximum pressure on the soles of the feet during the deviations of the body was perceived by mechanical-electronic transducer consisting of three sensors installed inside the platform. Recorded signal was processed from the analog information into digital, and then elaborated by computer program. The appropriate software created the possibility to calculate the resultant ground reaction force, which is the sum of the moments of the forces acting on the platform in three points of measurement. Vector addition of force moments allowed to designate the resultant ground reaction force at the moment, which is graphically presented as a dot on statokinesiogram. There was performed a standard stability rating test in a free-standing position (Romberg's Test). The test consisted of two successive samples lasting 30 seconds each: first with opened eyes (OE – *open eyes*), second with closed eyes (CE– *close eyes*). Measurements were taken in the morning. The tested person was carefully instructed about the test sequence. The silence has been assured during examination, because auditory stimuli acting on man in terms of attention can significantly impair the postural reflexes. The examined person has been ensured about the total harmlessness of the performed test. During the study, the investigator was behind the tested person all the time, not passing any messages. During the measurements with opened eyes (OE), the examined person has been asked to focus his sight on a point of reference located on the computer screen. The center of vision speckle was located at a distance of 1 meter from examined person. Before starting the test with closed eyes (CE), researcher made sure that the tested person is able to maintain an upright posture without visual control. The examined person stood on a platform barefoot, because shoes could interfere his posture. The feet were set with careful precision: heels 2 cm from each other, feet apart at the angle of 30 °, so that the center of gravity of a polygon base was in the sagittal axis of the platform at a distance of 3 cm from its center. To facilitate the correct positioning of the tested person, the platform was equipped with a pattern to keep the feet apart. The examined person took a habitual position with arms lowered along the torso and head straight. Test started at the time when investigated person took a posture, and on the screen the way of centre of feet pressure deviation was displayed. It has been analyzed the selected parameters, which records the centre of feet pressure deviations (COP):

1. Average load point X (Average COP X (provides lateral coordinates X (mm)).
2. Average load point Y (Average COP Y (provides anterior-posterior coordinates Y (mm)).
3. The mean deviation X (Medium-Lateral Standard Deviation X), is the mean oscillation along the X axis (mm) and medium lateral deviation (mm), which is the average distance between the extreme deviations of the centre of feet pressure in the lateral plane.
4. The mean deviation Y (Forward-Backward Standard Deviation Y). Is the mean oscillation along the Y axis (mm), medium anteroposterior deviation (mm) - the average distance between the extreme deviations of the centre of feet pressure in the sagittal plane.
5. Anteroposterior speed (Average Forward-Backward Speed), is the mean oscillation speed along the Y axis (mm/s). It is the length quotient of deviations of the centre of feet pressure

during the test, which indirectly informs about the dynamics of regulation process of postural stability in a standing position.

6. Lateral speed (Average Medium-Lateral Speed), is the mean oscillation speed along the X axis (mm/s). It is the length quotient of deviations of the centre of feet pressure during the test, which indirectly informs about the dynamics of regulation process of postural stability in a standing position.
7. Circumference P (Perimeter). It is the total length of the path traveled by the COP in both planes during the oscillation (mm).
8. EA area (Ellipse area). It is the total area which circled the COP in both planes during the oscillation (mm^2).
9. Circumference ratio (Perimeter ratio). It is the ratio of circumference (perimeter) with eyes closed (CE) to the circumference with eyes opened (OE) in Romberg's Test.
10. Surface ratio (Area ratio). It is the ratio of ellipse area with eyes closed (CE) to the ellipse area with eyes opened (OE) in Romberg's Test.

Variables were verified in terms of normal distribution by Shapiro-Wilk test. To determine the differences in postural reactions between scoliosis and scoliotic posture, Student's t-test has been used. Heterogeneity of variance and significance of the difference of observation rank sum in both trials required the use of a Mann–Whitney U-test. The level of significance was $p < 0,05$.

RESULTS

Based on the size of the angle of spinal curvature there were identified: scoliotic posture (1-9°) and scoliosis (≥10°). There were 21 (75%) children with scoliotic posture, and 7 (25%) with idiopathic scoliosis. The frequency and type of defect didn't depended on age (Tab. 1).

Postural reaction for Average COP X with opened eyes (OE) in scoliotic postures was 0,762 while in scoliosis 1,143. The difference between groups was 0,381. In the study with closed eyes (CE) COP X in scoliotic postures was 3,810 while in scoliosis 5,857. The difference between groups was 2,047. The difference in Romberg's Test for scoliotic postures was 3,048 and for scoliosis was slightly lower and it was 2,809. The difference in Romberg's Test for both groups was 0,239 (Tab. 2). Average COP Y with opened eyes (OE) in scoliotic postures was 4,048 while in scoliosis 4,429. The difference between groups was 0,381. In the study with closed eyes (CE) COP Y in scoliotic postures was 8,952 while in scoliosis 10,714.

The difference between groups was 1,762. The difference in Romberg's Test for scoliotic postures was 4,904 and for scoliosis was bigger and it was 6,285. The difference in Romberg's Test for both groups was 1,381 (Tab. 2). Postural reaction for Medium-Lateral Standard Deviation X with opened eyes (OE) in scoliotic postures was 3,619 while in scoliosis 4,714. The difference between groups was 1,095. In the examination with closed eyes (CE) Medium-Lateral Standard Deviation X in scoliotic postures was 4,714 while in scoliosis 8,00. The difference between groups was 3,286. The difference in Romberg's Test for scoliotic postures was 1,095 and for scoliosis was bigger and it was 3,286. The difference in Romberg's Test for both groups was 2,191 (Tab. 2). Postural reaction for Forward-Backward Standard Deviation Y with opened eyes (OE) in scoliotic postures was 6,238 while in scoliosis 7,571. The difference between the groups was 1,333. In the study with closed eyes (CE) Forward-Backward Standard Deviation Y in scoliotic postures was 6,571 while in scoliosis 9,571. The difference between the groups was 3,00. The difference in Romberg's Test for scoliotic postures was 0,333 and for scoliosis was bigger and it was 2,00. The difference in Romberg's Test for both groups was 1,667 (Tab. 2). Postural reaction for Average Forward-Backward Speed with opened eyes (OE) in scoliotic postures was 10,714 while in scoliosis 15,714. The difference between the groups was 5,00. In the examination with closed eyes (CE) Average Forward-Backward Speed in scoliotic postures was 16,286 while in scoliosis 20,286. The difference between the groups was 4,00. The difference in Romberg's Test for scoliotic postures was 5,572 and for scoliosis was smaller and it was 4,572. The difference in Romberg's Test for both groups was 1,00 (Tab. 2).

Postural reaction for Average Medium-Lateral Speed with opened eyes (OE) in scoliotic postures was 9,571 while in scoliosis 11,143. The difference between the groups was 1,572. In the examination with closed eyes (CE) Forward-Average Medium-Lateral Speed in scoliotic postures was 13,191 while in scoliosis 16,00. The difference between the groups was 2,809. The difference in Romberg's Test for scoliotic postures was 3,620 and for scoliosis was bigger and it was 4,857. The difference in Romberg's Test for both groups was 1,237 (Tab. 2). Postural reaction for Perimeter with opened eyes (OE) in scoliotic postures was 498,143 while in scoliosis 663,429. The difference between the groups was 165,286. In the study with closed eyes (CE) Perimeter in scoliotic postures was 719,00 while in scoliosis 879,143. The difference between the groups was 160,143. The difference in Romberg's Test for scoliotic postures was 220,857 and for scoliosis was slightly lower and it was 215,714. The difference in Romberg's Test for both groups was 5,143 (Tab. 2). Postural reaction for Ellipse area with opened eyes (OE) in scoliotic postures was 410,048 while in scoliosis 559,714. The difference between the groups was 149,666. In the examination with closed eyes (CE) Ellipse area in scoliotic postures was 642,381 while in scoliosis 1474,143. The difference between the groups was 831,762. The difference in Romberg's Test for scoliotic postures was 232,333 and for scoliosis was bigger and it was 914,429. The difference in Romberg's Test for both groups was 682,096 (Tab. 2). Perimeter ratio in scoliotic postures was 150,143 while in scoliosis was lower and it was 136,286. The difference between the groups was 13,857. Perimeter ratio is the proportion of Perimeter research with eyes closed (CE) to the Perimeter with opened eyes (OE). In scoliotic postures bigger differences were in Romberg's Test. Area ratio in scoliotic postures was 190,857 and in scoliosis was higher and it was 283,00. The difference for both groups was 92,143. Area ratio is the ratio of Ellipse area research with closed eyes (CE) to the examination with opened eyes (OE). In scoliosis bigger differences were in Romberg's Test (Tab.2). In scoliotic postures the differences in Romberg's Test were bigger for: Average COP Y, Average Forward-Backward Speed, Perimeter and Perimeter ratio. In scoliosis the differences in Romberg's Test were bigger for: Average COP Y, Medium-Lateral Standard Deviation X, Forward-Backward Standard Deviation Y, Average Medium-Lateral Speed, Ellipse area and Area ratio.

Student's t-test showed significantly higher postural reactions for scoliosis in relation to scoliotic postures in case of: Forward-Backward Speed (OE), (p=0,05), Medium-Lateral Standard Deviation X (CE), (p=0,002), and Ellipse area (CE), (p=0,012) (Tab. 2). To verify a significant differences showing a lack of homogeneity of variance, the Mann–Whitney U-test has been used. It demonstrated a significant differences between the scoliotic posture and scoliosis in case of: Medium-Lateral Standard Deviation X (CE), (p=0,0012), Average Forward-Backward Speed (OE), (p=0,0548), and Ellipse area (CE) (p=0,0047) (Tab. 3). With the increase of the angle of curvature, the value of mentioned postural reactions is growing. Most postural reactions didn't fit the norm.

DISCUSSION

Distortions stated in scoliosis are the result of a biological reaction system, aiming to restore the disturbed biomechanical balance of the spine. Analysis of compensation phenomenon in scoliosis confirms the opinion about the corrective nature of this process. The treatment of scoliosis is the desire to stop or reverse the biological corrective process and that's why it fails so often. Only in-depth knowledge of the pathogenesis and development of the scoliosis can indicate the appropriate ways of treating them. In developed scoliosis, musculoligamentous and bone changes are of a secondary nature, resulting from the uneven axial loading of the spine. Electrodiagnostic research didn't explain whether the changes of muscle tension on the convex and concave side of the curvature are primary or secondary. Interpretation of EMG results is different and often completely opposite. Asymmetric tension of back muscles is not caused by morphological changes in muscle tissue, but is created under the influence of changes in stimuli from CNS [13-15]. Primordial neurological changes causing the differences in muscle tension, may be located in different parts of CNS. In scoliosis, increasing attention is being paid to a discrete neurological changes. In the present state of knowledge, the theory of muscle tension imbalances as a pathobiomechanical cause of spinal curvature has got an important substantiation. The further stage of work on the etiology of scoliosis should focus around the issues associated with a regulation of back muscles tension [16-19]. In many publications about scoliosis, authors focus only on the spine, ignoring the postural effects of its deformation. The spine is a fundamental element of the supporting part of the skeleton, and its spatial arrangement also decides about the body posture. Apart from the sagittal plane, in which we talk about so-called physiological curvature of the spine, an essential feature of the physiological system of the spine in other planes is symmetry. Therefore, any shape irregularities of the spine can cause a change in a spatial system of the body, and thus they reflect on the posture of a person in whom these irregularities occur. Scoliosis is not an exception here. In a sufficiently advanced scoliosis most easily noticeable are their external manifestations - deviating from the normal system of body segments and body shape of a child. At this focuses the majority of reports about this subject, and elaborations considering about the way of keeping of the people with scoliosis are unfortunately rare. However, this problem must be noticed, because it has got a considerable practical importance. Among the phenomena of biomechanical nature, a significant impact for a correct posture in this plane have got the symmetrical burdens and tensions of passive and active stabilizers of the spine and the role played here by the antigravity muscles [20,21]. Constant element in development of scoliosis of unknown cause is an increase of the angle of curvature, up to a final value – sometimes significant. The dynamics and the degree of progression can be different. In some cases, problem becomes serious, but it's not the only problem. Central nervous system is constantly informed about changes in the body system, caused by developing scoliosis. Slight deviations from the generated pattern, are at the beginning corrected at the basis of functioning system of postural regulation, but when they become too large, CNS starts to treat them as a defect, which becomes a signal for activating the mechanisms of spontaneous compensation. It doesn't mean about the curvature compensation, but dominates the desire to secure the stable (balanced) system of the body as a whole. Therefore, there are compensating, linear movements of a different body segments, both rims mainly, although not all of them are purely linear. In a pathobiomechanical term, scoliosis is compensated when the original deflection goes smoothly into compensatory, proximal and distal deflection. Then the compensatory deflections are enough developed, and they equilibrate the original deflection. The sum of their angle values corresponds approximately to the angle value of original deflection. Plummet derived from the vertebra (C_7) falls then to a gluteal cleft, and lateral verticals are symmetrical. Head, shoulder girdle and pelvic girdle are positioned above each other. Decompensation of the trunk may occur during the rapid progression of scoliosis, as well as when bending compensations are too small, for example because of a too short arc or a lack of sufficient flexibility of the spine. Decompensation in the frontal plane is stated when the plummet lowered from the vertebra C_7 falls on the side of gluteal cleft on the way of primary curvature. The concept of compensation should also refer to the sagittal and transverse plane. Obtaining a compensation is one of the most important elements of a good result in treatment a child with scoliosis. A three-dimensional harmonic correction of scoliosis is a condition for obtaining a compensation in all three planes and it should take into account the correction of primary curvature and compensatory deflections. Compensatory deflections, primarily functional, may secondary become a structural deflections. A good measure of this balance is the observation of distribution of body weight on the supporting plane, which facilitates currently more common stabilographic platforms. They offer a vision of this balance, but they don't inform, what cost it takes. Body efforts associated with autonomous compensation often bring an unpredictable and not fully beneficial effect. The effects are most marked in the sphere of secondary and tertiary symptoms of scoliosis, so the system of the body is far from correct. Unequal symptoms of compensation results from the fact that the compensation abilities are an individual feature. In scoliosis we are dealing with a some kind of compromise between the deforming forces, and body's compensatory abilities of a person. Therefore, it is necessary to manage the compensation. Because some changes are relatively easy to see, they frequently becomes a subject of interest, so that the treatment procedure is usually focused on mitigation, and less perceived are general effects of postural scoliosis, concerning changes in the system of postural control. If the curvature maintains for a longer period of time, the system of postural regulation somehow gets used to it, and treats the abnormal structure of the body as something normal. In other words, the CNS creates and perpetuates a new pattern of posture, to which at any time is compared the current system of the body. Attempts of an active curvature correction and maintaining a proper posture becomes ineffective, because the system treats the correct posture as an error, and strives to restore the abnormal system of the body, in which a significant role plays, above-mentioned, a hyperactivity of contracted short muscles. In such situation, despite the mechanical correction of curvature, automatic maintenance of a proper system of the spine in the vertical position is not possible. Of course, we can control it for a short period of time, but just simple distraction is enough to make the automatically return of the spine to the faulty setting [1]. Therefore, the treatment of scoliosis is based on the skillful control of compensation processes. Conservative and operating treatment, guided only by the desire to straighten the curvature, can disrupt the nonlinear compensation, which secondary will cause the deterioration, often with the change of the shape and size of scoliosis.

CONCLUSIONS

1. Children with scoliosis had significantly higher values of postural reactions than those with scoliotic posture both in the studies with opened and closed eyes.
2. Scoliosis were accompanied by a significant increase of postural reactions.
3. Most of postural reactions didn't fit the norm both in children with scoliotic posture as well as scoliosis.

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Table 1. Faulty postures in the frontal plane and age

Independent variables	Age			
	7-11	12-14	15-18	Total
Scoliotic posture	6	10	5	21
% of column	75,00%	76,92%	71,43%	
% of row	28,57%	47,62%	23,81%	
% of total	21,43%	35,71%	17,86%	75,00%
Scoliosis	2	3	2	7
% of column	25,00%	23,08%	28,57%	
% of row	28,57%	42,86%	28,57%	
% of total	7,14%	10,71%	7,14%	25,00%
Total	8	13	7	28
% of total	28,57%	46,43%	25,00%	100,00%
$\chi^2 = 0{,}072$; df = 2; p = 0,96				

Table 2. Postural reactions with opened eyes (OE)

Dependent variables	Scoliosis	Scoliotic postures	t	DF	p	Scoliosis	Scoliotic postures	Scoliosis	Scoliotic postures	Quotient F of variance	Variance P
	x	x				n	n	s	s		
AX (OE)	1,143	0,762	0,979	26	0,3366	7	21	0,378	0,995	6,933	**0,0237**
AY (OE)	4,429	4,048	0,134	26	0,8945	7	21	6,106	6,637	1,181	0,9011
FBSD (OE)	7,571	6,238	1,211	26	0,2369	7	21	2,299	2,587	1,266	0,8235
MLSD (OE)	4,714	3,619	1,361	26	0,1852	7	21	2,059	1,774	1,346	0,5668
AFBS (OE)	15,714	10,714	2,199	26	**0,0370**	7	21	7,952	4,039	3,876	**0,0199**
AMLS (OE)	11,143	9,571	0,920	26	0,3659	7	21	3,761	3,957	1,107	0,9760
P (OE)	663,429	498,143	2,045	26	0,0511	7	21	229,316	169,728	1,825	0,2899
EA (OE)	559,714	410,048	1,095	26	0,2836	7	21	227,959	334,593	2,154	0,3470

Table 3. Postural reactions with closed eyes (CE)

Dependent variables	Scoliosis	Scoliotic postures	t	DF	p	Scoliosis	Scoliotic postures	Scoliosis	Scoliotic postures	of varianceQuotient F	Variance P
	x	x				n	n	s	s		
AX (CE)	5,857	3,810	1,140	26	0,2645	7	21	3,976	4,155	1,092	0,9921
AY (CE)	10,714	8,952	0,618	26	0,5421	7	21	4,071	7,110	3,050	0,1712
FBSD (CE)	9,571	6,571	2,041	26	0,0515	7	21	4,117	3,108	1,755	0,3198
MLSD (CE)	8,000	4,714	3,389	26	**0,0022**	7	21	3,606	1,586	5,170	**0,0047**
AFBS (CE)	20,286	16,286	1,364	26	0,1842	7	21	7,365	6,513	1,279	0,6222
AMLS (CE)	16,000	13,191	1,611	26	0,1193	7	21	4,761	3,737	1,623	0,3849
P (CE)	879,143	719,000	1,626	26	0,1161	7	21	255,919	215,854	1,406	0,5220
EA (CE)	1474,143	642,381	2,712	26	**0,0117**	7	21	1122,375	514,100	4,766	**0,0072**
PR	136,286	150,143	-0,867	26	0,3938	7	21	34,072	37,346	1,201	0,8820
AR	283,000	190,857	1,445	26	0,1604	7	21	207,248	121,947	2,888	0,0682

Table 4. Mann–Whitney U-test

Dependent variables	Scoliosis	Scoliotic postures	U	Z	Scoliosis	Scoliotic postures	p
	Sum rang	Suma rang			n	n	
MLSD (CE)	159	247	16	3,050709	7	21	**0,0012**
AFBS (OE)	138	268	37	1,936537	7	21	0,0548
EA (CE)	153	253	22	2,732374	7	21	**0,0047**