Original paper

Correlations between variables of posture and postural stability in children

Korelacje między zmiennymi postawy ciała i stabilnością posturalną u dzieci

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Key words: postural stability, body posture defects, variable body postures.

Słowa kluczowe: stabilność posturalna, wady postawy ciała, zmienne postawy ciała.

Abstract

Introduction: The results of postural re-education still being unsatisfactory are inspiration to search for new diagnostic and therapeutic methods. Despite the considerable strength and endurance of core muscles, body segments are often misaligned and even develop postural defects and scoliosis.
Aim of the research: To analyse the relationship between body posture variables and the stability of children's posture.
Material and methods: The study involved 301 children (age 10–12) from 3 different primary schools. Body posture examination was performed with the Diers formetric III 4D. Postural stability was evaluated via the Biodex Balance System platform.
Results: Canonical analysis of selected variables characterising postural stability (left set) and body posture (right set) allowed formation of significant canonical variables and were correlated at the level of ($R = 0.267$, $p = 0.002$). In canonical correlations regarding body posture defects the largest shares regarded: trunk length VP-SP (mm), trunk inclination VP-DM (°), trunk imbalance VP-DM (°), pelvic tilt in degrees (°), surface rotation (°) and lateral deviation VP-DM (max) (mm). In the case of variables concerning postural stability, the largest share was attributed to: OSI, percentage of time in quadrant III (%) and percentage of time in quadrant IV (%).
Conclusions: Significant correlations were found between the postural variables and postural stability. The higher the values of postural sway, the more pronounced the defects in body posture. Due to the significant relationship between posture variables and posture stability, there is a need to implement rehabilitation exercises in therapy to improve postural stability. Therefore, it is very important to be able to notice even discrete disturbances in the development of the antigravity system, perform qualitative analysis of postural and motor compensation patterns, and predict their consequences. Such an approach to the problem of posture defects will allow for the creation of rational, individually tailored therapeutic programs.

Streszczenie

Wprowadzenie: Nadal niezadowalające wyniki reedukacji wad postawy i skolioz były inspiracją do poszukiwania nowych metod diagnostycznych i terapeutycznych. Pomimo znacznej siły i wytrzymałości mięśni posturalnych często występują nieprawidłowe ułożenia segmentów ciała, a nawet mogą rozwinąć się wady postawy i skoliozy.
Cel pracy: Analiza związku między zmiennymi postawy ciała a stabilnością posturalną u dzieci.
Materiał i metody: W badaniu wzięło udział 301 dzieci (10–12 lat) z 3 różnych szkół podstawowych. Badanie postawy ciała wykonano aparatem Diers formetric III 4D. Stabilność posturalną oceniano za pomocą platformy Biodex Balance System.
Wyniki: Stwierdzono istotne korelacje między zmiennymi postawy ciała a stabilnością posturalną. W korelacjach kanonicznych dotyczących zmiennych stabilności postawy największy udział miały: wskaźnik ogólnej stabilności, procent czasu w kwadrancie III (%) oraz procent czasu w kwadrancie IV. Natomiast w przypadku zmiennych dotyczących postawy ciała największy udział dotyczył: długości tułowia VP-SP (mm), pochylenia tułowia VP-DM (°), nierównowagi tułowia VP-DM (°), pochylenia miednicy w stopniach (°), obrót powierzchni (°) i odchylenie boczne VP-DM (maks.) (mm). Im wyższe były wartości kołysania postawy ciała, tym wyraźniejsze były wady postawy ciała.
Wnioski: Ze względu na istotny związek między zmiennymi postawy a stabilnością postawy konieczne jest wdrożenie do terapii ćwiczeń rehabilitacyjnych poprawiających stabilność postawy. Dlatego bardzo ważna jest umiejętność zauważenia nawet dyskretnych zaburzeń w rozwoju układu antygrawitacyjnego, jakościowej analizy wzorców kompensacji postawy i motoryki oraz przewidywania ich konsekwencji. Takie podejście do problemu wad postawy pozwoli na stworzenie racjonalnych, indywidualnie dopasowanych programów terapeutycznych.

Introduction

Body posture is related to the structure of the bone-joint system and the muscular apparatus, but it is actually an external manifestation of the functioning of the neural postural system [1, 2]. Maintaining stable posture consists of constantly adjusting the activity of various muscle groups to changing biomechanical conditions resulting from the change of body position in space under the conditions of gravity [3, 4]. The essence of the problem of postural regulation is better reflected by the term "antigravity system". This system consists of postural tension, organization of opposed innervation, and proper coordination of postural and motor patterns. The proper functioning of this system plays a fundamental role in everyday movement, in which it is necessary to be able to move any of the various sections of the body while maintaining correct body positioning [5]. Body posture it is the result of genetic and environmental factors associated with a child's activity and established habits. For proper development of body posture, body balance, and stability are necessary [6, 7]. In postural re-education, too often, mechanical perception of the role of muscles causes unreasonable concentration on the formation of the so-called muscular corset, and more specifically, exercises that shape the strength and endurance of postural muscles [8]. This element of the mentioned procedure is obviously important, but the approach to the functioning of these muscles must be completely different [9, 10]. There is evidence that, despite the considerable strength and endurance of these muscles, abnormal positioning of the body is often assumed, and postural defects may even develop [11]. Postural re-education is not about local stretching or strengthening individual postural muscle groups, but about the integration of their function in relation to static, adjustment, and balance reactions [12]. The normalisation of postural tension is essential here, which, unlike muscle tension, is a form of perfect automatic coordination between the stability and mobility of individual body segments. The basic issue in this procedure should be shaping the habit of body posture.

Aim of the research

The aim of the study was to analyse the relationship between body posture variables and the stability of children's posture.

Material and methods

Material

The research was conducted at the beginning of 2016 in the Laboratory of Posturology at the Faculty of Medicine and Health Sciences in Kielce (Poland). All research procedures were carried out with the consent of the University Bioethics Board for Scientific Research at Jan Kochanowski University in Kielce (Poland) (Resolution No. 5/2015). The study involved 301 children, aged 10–12 years, from 3 primary schools. The total number of studied girls totalled 142 (47.18%), and boys equalled 159 (52.82%) subjects. The most numerous group (132 participants, 43.85%) comprised 10-year-old children, including 65 (49.24%) girls and 67 (50.76%) boys. In the group of 11-year-olds, there were 107 (35.55%) children, including 47 (43.93%) girls and 60 (56.07%) boys. The smallest research group (62 subjects, 20.60%) comprised 12-year-old children, including 30 (48.39%) girls and 32 (51.61%) boys. The subjects were selected randomly, after prior determination of the criteria to be met by individual groups.

Methods

Body posture was evaluated using a DIERS formetric III 4D device. This test took about 15 min. Body posture was examined twice. During measurements, the patient undressed to their shorts and positioned his/her back against the camera at a distance of 2 m [13]. The following parameters describing body posture were analysed in the test: trunk length VP-DM (mm) and VP-SP (mm), trunk inclination VP-DM (mm) and (°), trunk imbalance VP-DM (mm) and VP-DM (°), trunk torsion (°), pelvic tilt (°) and (mm), pelvic torsion DL-DR (°), pelvic inclination (°) (dimples) and (symmetry line) (°), inflection point ICT (mm), ILS (mm) and ITL (mm), kyphotic apex KA (VP-DM) (mm), kyphotic angle ICT-ITL (max) (°) and VP-ITL (°), lordotic angle ITL-ILS (max) (°) and ITL-DM (°), lordotic apex LA (VP-DM) (mm), surface rotation (rms) (°), lateral deviation VP-DM (rms) (mm) and (max) (mm), and dimple distance DL-DR (mm). The normal value for the kyphotic angle was 47–50°, while for lordosis this value was between 38° and 42°. On this basis, postural defects were distinguished. A round back occurs when the kyphotic angle is > 50°, and a concave back is observed when the lordotic angle is > 42°. Round-concave back appears in cases where kyphotic angle is > 50° and, at the same time, the lordotic angle is > 42°, while a flat back is considered when kyphotic angle is < 47° and the lordotic angle is < 38°. In the case of the remaining body posture variables, the norms were as follows: trunk inclination: VP-DM: ≤ 5 mm, ≤ 5°, trunk imbalance: VP-DM: ≤ 4 mm, ≤ 4°, pelvic tilt: DL-DR: ≤ 4°, ≤ 4 mm, (°) ≤ 4°, pelvic inclination (dimples): ≤ 4°, pelvic torsion: DL-DR: ≤ 2°, surface rotation (rms): ≤ 4°, lateral deviation: VP-DM (rms): ≤ 4 mm, VP-DM (max) ≤ 4 mm. Scoliotic posture occurred when the pelvic tilt was 1–5 mm, while at the same time, lateral deviation was between 1 and 5 mm and surface rotation equalled 1–5°. In the case of scoliosis, its occurrence was noted when pelvic tilt and lateral deviation were greater than 5 mm (> 5 mm) while surface rotation was greater than 5° (> 5°). For scoliosis or scoliotic posture to be assessed, all 3 conditions had to be met. In the absence of these 3 requirements, it is assumed that scoliotic posture or scoliosis were not present [13].

Postural stability was evaluated using the Biodex Balance System platform. The Postural Stability Test was performed with the subject positioning both feet on a stable surface, eyes open, and arms along the body. The platform was blocked so that it was rigid and fully stable. After personal data and body height were introduced into the system, the patient's position was determined. For this purpose, the centre line of the foot and platform axes were used as reference points. The position was determined by entering the angles of position of the feet visible on the screen of the device, using the centre line separately for the right and left foot. The Postural Stability Test consisted of three 20-second trials, divided by a 10-second interval. Postural stability was examined 3 times. The Overall Stability Index (°) represents the variance of foot platform displacement in degrees from its level, in all motions performed during the test. A high number is indicative of a lot of movement during a test with static measures; it is the angular excursion of the patient's centre of gravity. The Anterior/Posterior Stability Index (°) represents the variance of foot platform displacement in degrees from horizontal for motion in the sagittal plane. The Medial/Lateral Stability Index (°) concerns the variance of foot platform displacement in degrees from horizontal, for motions in the frontal plane [14]. The percentage of time in a zone (%) is an index representing the time spent by a patient in a given zone. Target zones A, B, C, and D are equal with respect to the degree of platform tilt. They are determined by concentric circles with the middle in the centre of the platform. In the test, 4 zones were distinguished: Zone A: from 0 to 5° deviation with respect to the horizontal plane, Zone B: from 6° to 10° deviation with respect to the horizontal plane, Zone C: from 11 to 15° deviation with respect to the horizontal plane, Zone D: from 16° to 20° deviation with respect to the horizontal plane. Time in Quadrant (%) is an index presenting the amount of time spent by a patient spent in a given quadrant. In the test, 4 quadrants of the test graph between X and Y axes were distinguished: Quadrant 1: right anterior, Quadrant 2: left anterior, Quadrant 3: left posterior, Quadrant 4: right posterior. The patient's scoring in the Postural Stability Test depended on the number of sways from the centre, which means that the lower the result, the better the postural stability. All the parameters registered by the posturological platform were collected in a non-invasive manner, making sure device was safe for the whole group [15].

Statistical analysis

Variables were verified in terms of normality of distribution using the Shapiro-Wilk test. The differences between types of body posture in the sagittal and frontal planes were estimated using the *p* structure test, while differences in postural stability among boys and girls were determined using Student's *t*-test. To distinguish variables without correlations, factor analysis was conducted. The relationship between postural stability and body posture variables was determined by canonical correlations. The significance level was set at $p < 0.05$.

Results

In the group of examined girls, the majority (41, 28.87%) demonstrated posture characterised by reduced kyphosis and normal lordosis as well as posture with correct physiological spinal curvatures (36, 25.35%). Posture with reduced kyphosis and lordosis (flat back) was exhibited by 22 (15.4%) of those examined, and posture exhibiting normal kyphosis as well as increased lordosis (concave back) concerned 18 (12.68%) girls. Posture with reduced kyphosis and increased lordosis was present in 12 (8.45%) of the subjects, while posture demonstrating increased kyphosis and increased lordosis (round-concave back) were present in 10 (7.04%) girls. Posture showing signs of increased kyphosis and normal lordosis (round back) was found in 2 (1.41%) girls, while 1 (0.7%) subject demonstrated posture with normal kyphosis and reduced lordosis. Among the boys, posture with normal physiological curvature of the spine prevailed in 51 (32.08%) cases. Those with reduced kyphosis and lordosis (flat back) and with reduced kyphosis and normal lordosis totalled the same number – 26 (16.35%). Male subjects exhibiting normal kyphosis and increased lordosis equalled 17 (10.69%), posture with normal kyphosis and reduced lordosis – 16 (10.06%), increased kyphosis and lordosis (round-concave back) – 11 (6.92%), and with increased kyphosis and normal lordosis (round back) – 10 (6.29%). The smallest group – 2 (1.26%) – comprised boys with reduced kyphosis and increased lordosis. Significant differences were found between girls and boys regarding posture characterised by reduced kyphosis and normal lordosis ($p = 0.009$), decreased kyphosis and increased lordosis ($p = 0.003$), normal kyphosis and reduced lordosis ($p = 0.001$), and increased kyphosis and normal lordosis (round back) ($p = 0.030$). Over half of the tested children demonstrated scoliotic posture, and a small group comprised individuals with scoliosis (Table 1).

In girls, the average value of the Overall Stability Index was 0.63°, Anterior-Posterior Stability Index totalled 0.331°, while the Medial-Lateral Stability Index equalled 0.226°. The girls spent 99.923% of the test time in zone A. Most of them had a tendency towards right, rear sways – square IV, where they spent 51.739% of the test time. Among boys, the mean value of the Overall Stability Index was 0.599°, the value of the Anterior-Posterior Stability Index averaged 0.431°,

Table 1. Body posture of girls and boys in the sagittal and frontal planes

Variables	Girls		Boys		Total		Structure indicator test *p*
	n	%	*n*	%	*n*	%	
Characteristics of body posture in the sagittal plane:							
Reduced kyphosis, reduced lordosis (flat back)	22	15.49	26	16.35	48	15.95	0.838
Reduced kyphosis, normal lordosis	41	28.87	26	16.35	67	22.26	0.009
Reduced kyphosis, enlarged lordosis	12	8.45	2	1.26	14	4.65	0.003
Correct kyphosis, reduced lordosis	1	0.7	16	10.06	17	5.65	0.001
Correct posture	36	25.35	51	32.08	87	28.9	0.198
Correct kyphosis, enlarged lordosis (back concave)	18	12.68	17	10.69	35	11.63	0.591
Enlarged kyphosis, correct lordosis (round back)	2	1.41	10	6.29	12	3.99	0.030
Enlarged kyphosis, enlarged lordosis (round back – concave)	10	7.04	11	6.92	21	6.98	0.966
Total	142	47.18	159	52.82	301	100	
Characteristics of body posture in the frontal plane:							
Correct posture	58	40.85	71	44.65	129	42.86	0.505
Scoliotic posture	76	53.52	85	53.46	161	53.49	0.991
Scoliosis	8	5.63	3	1.89	11	3.65	0.083
Total	142	47.18	159	52,82	301	100	

Table 2. Differences in postural stability between girls and boys

Variables	Girls			Boys			*t*	d*f*	*P*-value
	n	*x*	*s*	*n*	*x*	*s*			
Overall Stability Index [°]	142	0.463	0.247	159	0.599	0.396	–3.547	299	0.001
Anterior-Posterior Stability Index [°]	142	0.331	0.174	159	0.431	0.284	–3.626	299	0.001
Medial-Lateral Stability Index [°]	142	0.226	0.172	159	0.304	0.247	–3.134	299	0.001
Percentage of time in zone A (%)	142	99.923	0.620	159	99.756	1.146	1.564	299	0.121
Percentage of time in quadrant I	142	26.852	14.254	159	28.956	13.366	–1.321	299	0.187
Percentage of time in quadrant II	142	8.972	8.551	159	11.956	11.188	–2.576	299	0.01
Percentage of time in quadrant III	142	12.359	8.966	159	13.333	9.946	–0.888	299	0.375
Percentage of time in quadrant IV	142	51.739	16.826	159	45.755	18.715	2.904	299	0.003

while Medial-Lateral Stability Index reached 0.304°. The boys spent 99.755% of the test time in zone A. Most often, they leaned towards the rear right – square IV, 45.755% (Table 2). Significant differences between girls and boys were noted for Overall Stability Index (p = 0.001), Anterior-Posterior Stability Index (p = 0.001), Medial-Lateral Stability Index (p = 0.001), and body inclination in the left front (square II) (p = 0.010) and right rear directions (square IV) (p = 0.003). During the postural stability measurements, all the children remained in study Zone A (0-5). Most of them had a right-backward sway tendency (Quadrant IV) (Table 2). In canonical correlations regarding the variables of postural stability, the largest share (absolute value of canonical weight) was attributed to: Overall Stability Index (–1.052°), the percentage of time in Quadrant III (0.106%), and the percentage of time in Quadrant IV (–0.156%). While in the case of variables concerning body posture, the largest share regarded trunk length VP-SP (0.409 mm), trunk inclination VP-DM (0.077°), trunk imbalance VP-DM (–0.057°), pelvic tilt (0.188°), surface rotation (–0.678°), and lateral deviation VP-DM (max) (0.456 mm). Of the 3 essential elements (solutions), the first was selected for its greatest substantive value (sensibility of canonical variables determined by the weights of the individual constituent variables). Canonical analysis of selected variables that character-

Table 3. Canonical weights regarding variables of postural stability and body posture defects

Canonical weights							
Left set				Right set			
Variables	**Elem 1**	**Elem 2**	**Elem 3**	**Variables**	**Elem 1**	**Elem 2**	**Elem 3**
Overall Stability Index [°]	–1.052	–0.248	0.146	Trunk length VP-SP (mm)	0.409	–0.699	0.109
Percentage of time in quadrant III	0.106	0.093	1.026	Trunk inclination VP-DM	0.077	0.298	0.731
Percentage of time in quadrant IV	–0.156	–1.044	0.387	Trunk imbalance VP-DM	–0.057	–0.260	–0.396
				Pelvic tilt in degrees	0.188	0.739	0.049
				Lordosis angle ITL-DM	0.188	0.377	–0.109
				Surface rotation	–0.678	–0.150	0.072
				Lateral deviation VP-DM (max) [mm]	0.456	0.137	–0.507

	Summary of canonical analysis	
	Left set	**Right set**
Number of variables	3	7
Isolated variation	100%	45.22%
Total redundancy	4.94%	2.09%
Variables	Variables of postural stability	Variables of body posture defects
1	Overall Stability Index (°)	Trunk length VP-SP [mm]
2	Percentage of time in quadrant III	Trunk inclination VP-DM
3	Percentage of time in quadrant IV	Trunk imbalance VP-DM
		Pelvic tilt in degrees
		Lordosis angle ITL-DM
		Surface rotation
		Lateral deviation VP-DM (max) [mm]

$R = 0.267$; χ^2 (21) = 43.345; $p = 0.002$,

ise postural stability (left set) and the variables that characterise body posture (right set) allowed for the formation of significant canonical variables and were correlated at the level $R = 0.26781$ ($p < 0.003$) (Table 3).

Discussion

In our study, there were significant correlations between postural stability and postural defects. In canonical correlations regarding the variables of postural stability, the largest share was attributed to the Overall Stability Index, the percentage of time in Quadrant III (%), and the percentage of time in Quadrant IV. While in the case of variables concerning body posture the largest share regarded trunk length VP-SP (mm), trunk inclination VP-DM (°), trunk imbalance VP-DM (°), pelvic tilt (°), surface rotation (°), and lateral deviation VP-DM (max) (mm). Canonical analysis of selected variables that characterise postural stability and the variables that characterise body posture allowed for the formation of significant canonical variables and were correlated at the level $p < 0.003$. The postural defects observed in research are the result of dysfunction associated with the central nervous system as well as the antigravity system. Postural tension plays a key role in their functioning [1]. The development of this tension is a dynamic process that consists of shaping possibilities for automatic adjustment of functions related to many muscle groups. Postural tension is the basis of stability and dynamic postural control in various positions. Correct postural tension allows the forces of gravity to be counteracted [1]. This is done taking current needs and possibilities into account, which are further determined by the central nervous system's degree of maturation. In contrast to muscle tension, postural tension is a form of perfect, automatic coordination between the stability and mobility of individual body segments adjusted to the type of physical activity performed. During normal development, postural tension must undergo diametric transformation from distal stability and proximal mobility in the neonatal period to the image of proximal stability and distal mobility observed at the end of the first year of life [11]. The peak of functional capacity is the full automation of assuming and maintaining a standing position, ensuring optimal arrangement of body segments – defined as stereotypical body posture. As a result of postural hypotonia, children become inefficient at overcoming the forces of gravity at particular stages of postural development. The possibility of assuming higher and higher body positions is ensured by the compensational anti-gravitational system, which is constantly activated in such cases [1]. A child with impaired development of postural tension, unable to sufficiently stabilise the proximal segments of the body, compensates for these deficiencies by intrinsically activating substitute stabilisation. Passive stabilisation occurs through manipulation of the support plane and projection of the centre of gravity, or through the use of passive, periarticular elements, so-called hanging from ligaments [1]. The second method of compensation is proximal or distal stabilisation, i.e. fixation triggered on the basis of reflexive tonic reactions. Both methods enforce compulsory alignment of specific body segments. The postural consequences of passive substitutive stabilisation are primarily nonaxial positions of individual body segments, in the present study, considered defects of posture in the sagittal and frontal planes [11]. In some children, excessive front and backward tilt of the trunk occur, or lateral displacement of the trunk in relation to the pelvic girdle. This results in positioning of body segments causing projection of the centre of gravity to extend beyond the boundaries of the support quadrilateral [11]. The system used in the compensation for deviations of body segments in the sagittal plane usually involves the spine, sacrum, and pelvis. Displacement of any of the segments involves immediate displacement of adjacent sections in opposite directions. Thus, the entire compensatory antigravity system is created, in which incorrect settings apply to all body control elements, starting from the pelvis, to the joints of the spine, the position of the head, and from the pelvis, down through the knee joints, to positioning of the feet [1]. Most often, spinal lordosis is accompanied by pelvic retroflection, excessive flexion of the hip joints, hyperextension in the knee joints, and heel overload. In children with a tendency towards kyphothesis of the spine, pelvic tilt, excessive flexion in the knee joints, and overloading of the forefoot are most frequently observed. As a result of compensatory deviations of body segments in the frontal plane, asymmetry of the trunk and pelvic rotation start to develop [1]. This is usually accompanied by internal rotation of the thigh, causing valgus knee or ankle deformities. In children with proximal postural hypotension, the development of head control is disturbed. This promotes the consolidation of fragments of asymmetric tonic reactions in the form of large extension and flexion synergies in postural and motor patterns. Then, body mass is unevenly distributed onto the lower limbs. A characteristic element of both asymmetric compensating mechanisms is pelvic rotation in the flexion mechanism, which was observed in this study [1]. This takes place towards the front on the overloaded side as well as in the backward flexion mechanism. A similar situation concerns excessive distal stabilisation, which is manifested by irregularities in the positioning of the lower limb joints in both planes. Therefore, the ability to notice even discrete disturbances in the development of the antigravity system, the quality analysis of compensatory postural and motor patterns, as well as the anticipation of their consequences, are greatly important [11]. This approach to the problem of postural defects will allow the creation of rational, individually tailored therapeutic programmes [1]. Defective posture is the result of a child's lack of ability to withstand the forces of gravity. When one of the elements of perfect synchronisation, mutual conditions or relations of many links of the antigravity system are disturbed, numerous changes, secondary in nature, may occur within the remaining elements. They can even include structural changes within the musculoskeletal system. Here, an example may be idiopathic scoliosis, in which dysfunction of the central postural control system at the initial period of individual development first causes disorders related to postural and movement patterns, and then the function and structure of the muscle apparatus, and eventually deformations of the osteoarticular system [11]. Nonetheless, the range of probable abnormalities can be very wide here. This range may even include children in whom these disorders manifest themselves only in the form of compensating for basic postural patterns [1]. Further development and adaptation to the function of patterns, compensatory in nature, tend to shift only in the direction of pathological postural stereotypes, i.e. disorders of body posture. In the presented study, there were significant correlations between postural stability and postural defects. The higher the values of postural sway, the more pronounced the defects in body posture [11]. As early as in 1969, a group of researchers reported dysfunction in proprioceptive postural reflexes in 57 scoliosis cases among 70 individuals examined, and only one case in the 20-subject control group. They confirmed a significant correlation between postural stability and the angle of curvature, progression rate, and the degree of skeletal maturity. According to their research, delayed development of postural stability may be an aetiological factor in idiopathic scoliosis [16]. The results of this study were confirmed by two other researchers [17, 18], who observed considerably worse postural control in children with scoliosis compared to those who were healthy. These researchers suggested that postural stability disorders may be a causative factor in juvenile-type idiopathic scoliosis. Other research [19] demonstrated dynamic and static balance in idiopathic scoliosis, and according to the authors, scoliosis disturbs balance. In turn, another study [20] investigated the parameters of static and dynamic balance in 14-year-old girls with kyphosis and compared the results with children lacking defects. The author found considerable differences between groups; the mean parameters of dynamic balance were worse in girls with hyperkyphosis. Other researchers assessed postural control with open and closed eyes in idiopathic scoliosis and among healthy individuals. They demonstrated a weaker ability to maintain balance in people with scoliosis compared to healthy individuals [20]. In recent years, many researchers have been engaged in posturographic studies in lateral curvatures of the spine [21–23]. These researchers indicated significant relationships between balance reactions and postural defects [24, 25]. The available literature is dominated by works showing significant relationships between postural stability, postural defects, and scoliosis [26, 27]. Therefore, it is very important to be able to notice even discrete disturbances in the development of the antigravity system, qualitative analysis of postural and motor compensation patterns, and predict their consequences.

Conclusions

Significant correlations were found between the postural variables and postural stability. The higher the values of postural sway, the more pronounced the defects in body posture. Due to the significant relationship between posture variables and posture stability, there is a need to implement rehabilitation exercises in therapy to improve postural stability. Therefore, it is very important to be able to notice even discrete disturbances in the development of the antigravity system, to perform qualitative analysis of postural and motor compensation patterns, and to predict their consequences. Such an approach to the problem of posture defects will allow for the creation of rational, individually tailored therapeutic programs.

Conflict of interest

The authors declare no conflict of interest.

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