Asymmetries of the shoulder and pelvic girdles in girls with scoliosis and scoliotic posture

Asymetrie obręczy barkowej i biodrowej u dziewcząt z bocznym skrzywieniem kręgosłupa i postawą skoliotyczną

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Key words: shoulder girdle asymmetry, hip girdle asymmetry, scoliosis.

Słowa kluczowe: asymetria obręczy barkowej, asymetria obręczy biodrowej, boczne skrzywienie kręgosłupa.

Abstract

Aim of the research: To evaluate the asymmetries of the shoulder and pelvic girdles in girls aged 7–18 with scoliosis and scoliotic posture.
Material and methods: The children were enrolled at the *Międzyszkolny Ośrodek Gimnastyki Korekcyjnej i Kompensacyjnej* (Interschool Corrective and Compensatory Gymnastics Centre) in Starachowice. The research was carried out in June 2011. 3D digital photogrammetry using the moiré effect was adopted in the research. Depending on the conformity of the variables' distributions with the normal distribution, and the values of skewness and kurtosis, parametric or non-parametric tests were adopted. The variables were verified in terms of normal distribution with the Shapiro-Wilk test. A screening analysis of the parameters of physiological curvatures of the spine in age groups was also carried out. The relation between the frequency and type of disorders in the frontal plane and age was determined using the χ^2 test. Value of $p \leq 0.05$ was assumed as the level of significance.
Results: Based on the size of the angle of the curvature of the spine the following were singled out scoliotic posture (1–9°) and idiopathic scoliosis (≥ 10°). There were 21 (75%) children with the scoliotic posture and 7 (25%) with idiopathic scoliosis. The frequency and type of disorders in the frontal plane does not depend on the age of the examined. Asymmetry of the shoulders and shoulder blades was found in all of the examined. The left shoulder along with the left shoulder blade were raised more often. The right side of the pelvis was lowered in most of the examined. Posterior rotation of the left hip bone occurred more often.
Conclusions: The values of WBM, WBK and WBC asymmetry coefficients confirm the asymmetry of the shoulder and hip girdles. Analysis of variance did not show any significant relations of asymmetry of the shoulder and hip girdles and the age of the examined.

Streszczenie

Cel pracy: Ocena asymetrii obręczy barkowej i biodrowej u dziewcząt w wieku 7–18 lat ze skoliozą i postawą skoliotyczną.
Materiał i metody: Grupę badaną stanowiły dzieci zapisane do Międzyszkolnego Ośrodka Gimnastyki Korekcyjnej i Kompensacyjnej w Starachowicach. W badaniach wykonanych w czerwcu 2011 roku zastosowano komputerową fotogrametrię przestrzenną wykorzystującą efekt moiré. W zależności od zgodności rozkładów zmiennych z rozkładem normalnym oraz wartości skośności i kurtozy zastosowano testy parametryczne lub nieparametryczne. Zmienne zweryfikowano pod względem normalności rozkładu testem Shapiro-Wilka. Przeprowadzono także przesiewową analizę wariancji parametrów fizjologicznych krzywizn kręgosłupa w grupach wiekowych. Związek częstości i rodzaju wad w płaszczyźnie czołowej z wiekiem określono za pomocą testu χ^2. Jako poziom istotności przyjęto $p \leq 0{,}05$.
Wyniki: Na podstawie wielkości kąta skrzywienia kręgosłupa wyodrębniono postawę skoliotyczną (1–9°) i boczne idiopatyczne skrzywienie kręgosłupa (≥ 10°); dzieci z postawą skoliotyczną było 21 (75%), a z bocznym idiopatycznym skrzywieniem kręgosłupa 7 (25%). Częstość i rodzaj wad w płaszczyźnie czołowej nie zależą od wieku badanych. U wszystkich badanych zaobserwowano asymetrię barków i łopatek. Częściej wyżej uniesione były lewy bark wraz z lewą łopatką. U większości badanych stwierdzono obniżoną prawą stronę miednicy. Częściej występowała rotacja tylna lewej kości biodrowej.
Wnioski: Wartości współczynników asymetrii WBM, WBK, WBC potwierdzają asymetrię obręczy barkowej i miednicznej. Analiza wariancji nie wykazała istotnych związków asymetrii obręczy barkowej i biodrowej z wiekiem badanych.

Introduction

When examining the posture of a child's body, one tries to determine if one is dealing with an idiopathic scoliosis and what the risk of its progression is. The positions of the shoulder girdle and the shoulder blades as well as the pelvic girdle and the iliac spine should also be evaluated. Asymmetric changes in these structures usually precede the emergence of scoliosis and are connected with a scoliotic posture. A scoliotic posture is a tendency to tilt the axis of the spine from its straight alignment, connected rather with an improper manner of bearing the body. Each spontaneously developing scoliosis is at the very beginning a small-angle curvature (a scoliotic posture) and only with time do its real developmental tendencies come to light. Double-arched curvatures, however, cannot be called a scoliotic posture, even when both angles are less than 10°, because the manifestation of a second arc is already a sign of compensation of an actual scoliosis [1]. It is impossible to determine whether the changes in the position of both girdles are the cause of the scoliosis but it is known that such an arrangement limits the possibilities for correction, and thus perpetuates the defect. Lowering and protrusion of the anterior superior iliac spine is not a result of passive changes in the shape of the pelvis, but an active compensative activity of the muscles of the third group, responsible for the connection between the spine and the pelvis. Such asymmetry can be observed in major scoliosis, but also in children with slight symptoms. That is why there is a low probability of this being a sign of spontaneous compensation of the curvature.

Aim of the research

Therefore, one should aim to re-establish and restore the stabilising function of the pelvic girdle and the sacroiliac joint and the shoulder girdle [2–5]. The aim of the research was to evaluate the asymmetry of the shoulder and pelvic girdles in girls aged 7–18 with scoliosis and a scoliotic posture.

Material and methods

Twenty-eight girls aged 7–18 with scoliosis and a scoliotic posture were included in the research. Selection of the examined people was deliberate. The children were registered in the *Międzyszkolny Ośrodek Gimnastyki Korekcyjnej i Kompensacyjnej* (Interschool Corrective and Compensatory Gymnastics Centre) in Starachowice. The research was carried out in June 2011. 3D digital photogrammetry using the moiré effect was adopted in the examination of body posture (Figures 1–4) [6]. An evaluation was made of the asymmetry of the shoulder and pelvic girdles in girls aged 7–18 (Table 1).

Statistical analysis

Depending on the conformity of the variables' distributions with the normal distribution, and the values of skewness and kurtosis, parametric or nonparametric tests were adopted. The variables were verified

Figure 1. An apparatus for examination using the moiré effect [6]

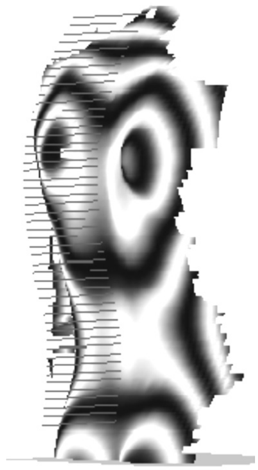

Figure 2. An image of the back with marked contour lines and a cross-section of the body in the sagittal and transverse planes [6]

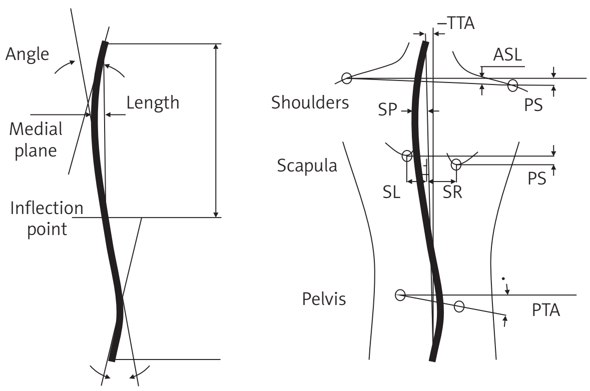

Figure 3. Anthropometric points of the spine for the frontal plane [6]

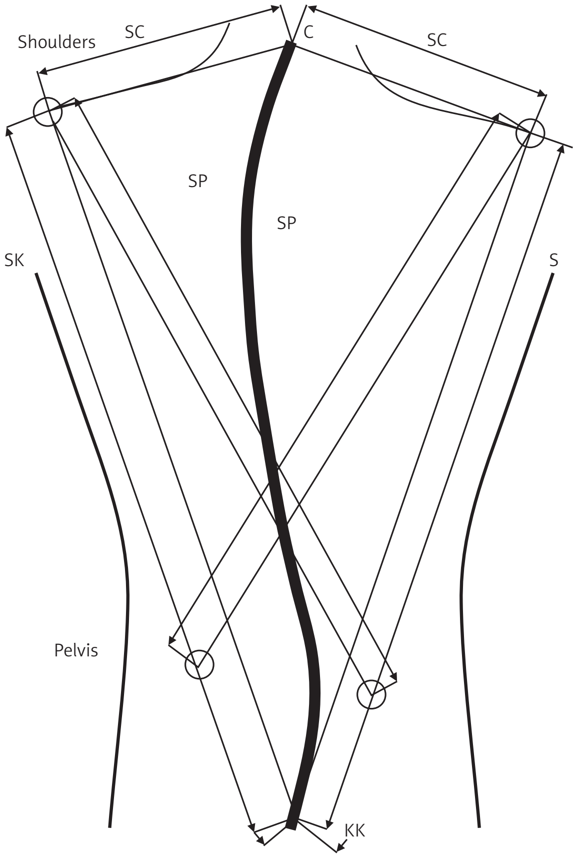

Figure 4. Anthropometric points and sections of the spine used for determining the coefficients of asymmetry [6]

in terms of normal distribution with the Shapiro-Wilk test. Analysis of variance with data screening was used to determine the relationship between the parameters of posture and age of the examined. The connection between the frequency and type of defects in the frontal plane and age was determined using the χ^2 test. Value of $p \leq 0.05$ was assumed as the level of significance [7].

Results

The examined were divided into the following three age groups: 7–11 years old, 12–14 years old and 15–18 years old. There were 8 (28.57%) girls in the 7–11 group, 13 (46.43%) in the 12–14 group and 7 (25.00%) in the 15–18 range (Table 2). Body height, body mass and body mass index (BMI) of the examined were also ascertained (Tables 3, 4, Figure 5). Analysis of variance with data screening showed significant relationships between BMI and the age of the examined ($p \leq 0.05$) (Table 5). Based on the size of the angle of the curvature of the spine the following were singled out scoliotic posture (1–9°) and an idiopathic scoliosis (≥ 10°). There were 21 (75%) children with a scoliotic posture and 7 (25%) with idiopathic scoliosis. The frequency and type of defects in the frontal plane do not depend on the age of the examined (Table 6, Figure 6).

In the examined group, asymmetry of the right shoulder (ABP) amounted to 2.61 mm, and of the left (ABL) to 6.07 mm (Table 7). In the range of 7–11, asymmetry of the right shoulder amounted to 1.0 mm, and of the left to 4.75 mm; in the 12–14 range, asymmetry of the right shoulder amounted to 2.92 mm, and of the left to 8.15 mm; and in the 15–18 group, asymmetry of the right shoulder amounted to 3.86 mm, and of the left to 3.71 mm (Tables 8–10). The angle of the shoulder line (KLB) was 1.39° for the whole group (Table 7). In the 7–11 range, this angle was 5.88°; in the 12–14 range it was slightly smaller – 5.31°; and in the 15–18 group it was the largest – 6.0° (Tables 8–10). For the whole group, asymmetry of the right scapula (ALP) amounted to 2.86 mm, and asymmetry of the left scapula (ALL) to 2.25 mm (Table 7). In the 7–11 range, asymmetry of the right scapula amounted to 3.25 mm, and asymmetry of the left scapula to 0.5 mm; in the 12–14 range, asymmetry of the right scapula amounted to 1.92 mm, and asymmetry of the left scapula to 3.23 mm; and in the 15–18 group, asymmetry of the right scapula amounted to 4.14 mm, and asymmetry of the left scapula to 2.43 mm. Asymmetry of the shoulders and shoulder blades was found in all of the examined. It was more often the left shoulder along with the left shoulder blade that were raised (Tables 8–10). The value of the pelvic-tilt angle (KNM) was 1.68° for the whole group (Table 7). In the 7–11 range, this angle was 1.13°; in the 12–14 range, it was slightly larger – 1.77°; and in the 15–18 group, it was the largest 2.14° (Tables 8–10).

The value of the pelvic-torsion angle (KSM) was 3.39° for the whole group (Table 7). In the 7–11 range, this angle was the largest and amounted to 4.25°; in the 12–14 range, it was slightly smaller – 3.15°; and in the 15–18 group, it was the smallest – 2.86°. Posterior rotation of the left hip bone occurred more often (counter-clockwise pelvic rotation) (Tables 8–10). The value of the shoulders-pelvis asymmetry coefficient (WBM) was 99.64% for the whole group (Table 7). In the 7–11 range, WBM amounted to 102.13%; in the 12–14 range, it amounted to 97.46%; and in the 15–18 group to 100.86% (Tables 7–9). The shoulders-KK asymmetry coefficient (WBK) was 101.68 % for the whole group (Table 7). In the 7–11 range, WBK amounted to 102.13%; in the 12–14 range it amounted to 101.77%; and in the 15–18 group it had the value of 101.00% (Tables 8–10). The asymmetry coefficient of shoulders in relation to C_7 (WBC) was 105.00 % for the whole group (Table 7). In the 7–11 range, WBC amounted to 105.88%; in the 12–14 range, it amounted to 103.77%; and in the 15–18 group it had the value of 106.29% (Tables 8–10). Analysis of variance with data screening did not show any significant relationships between the parameters of posture and the age of the examined (Table 11).

Table 1. Description of posture parameters in the frontal plane [6]

Posture parameters	Full name of the parameter	Description of the method of calculating the parameter
ABP	Asymmetry of shoulders – right one higher [mm]	The difference in the height of shoulders (right one higher)
ABL	Asymmetry of shoulders – left one higher [mm]	The difference in the height of shoulders (left one higher)
KLB	The angle of the shoulder line [°]	Lowering of the left shoulder (– value) Lowering of the right shoulder (+ value)
ALP	Asymmetry of the scapula – right one higher [mm]	The difference in height of the tips of the corners of the shoulder blades (right one higher)
ALL	Asymmetry of the scapula – left one higher [mm]	The difference in height of the tips of the corners of the shoulder blades (left one higher)
KNM	Pelvic-tilt angle [°]	Lowering of the left side of the pelvis (– value) Lowering of the right side of the pelvis (+ value)
KSM	Pelvic-torsion angle [°]	Clockwise rotation of the pelvis (+ value) Counter-clockwise rotation of the pelvis (– value)
WBM	Shoulder-pelvis asymmetry coefficient [%]	A percentage ratio of the distance between the left shoulder and the right point of the pelvis to the distance between the right shoulder and the left point of the pelvis
WBK	The asymmetry coefficient of shoulder – KK [%]	A percentage ratio of the distance between the left and right shoulders from the KK point
WBC	The asymmetry coefficient of shoulder – C_7 [%]	A percentage ratio of the distance between the left and right shoulders from the C_7 point
UB	Position of the shoulders	The difference between the height of the shoulders (> 0 left is higher)
UL	Position of the shoulder blades	The difference in the height of the tips of the corners of the shoulder blades (> 0 left is higher)
OL	The distance between the shoulder blades	The difference of the distances of the shoulder blades from the dl-dp spinal line (> 0 left is farther)

Table 2. The number and age of the examined

Age groups [years]	*N*	*X*	SD	Min.	Max.
7–11	8	9.88	1.46	7	11
12–14	13	13.15	0.80	12	14
15–18	7	16.43	1.13	15	18
Total	28	13.04	2.66	7	18

n – number of examined, x – mean, min. – minimal value, max. – maximal value, SD – standard deviation

Table 3. Anthropometric parameters of the examined

Anthropometric parameters	*N*	*X*	Med.	Min.	Max.	*R*	SD	SKEW	*K*
Body height	28	153.39	154	120	174	54	13.04	–0.594	0.121
Body mass	28	43.14	45.5	19	60	41	9.76	–0.630	–0.085
Body mass index	28	18.05	18.35	13.19	22.21	9.01	2.04	–0.264	–0.159

n – number of examined, x – mean, med. – median, min. – minimal value, max. – maximal value, r – range, skew – skewness, k – kurtosis, SD – standard deviation

Table 4. Body mass index in age groups

Age groups	BMI				
	X	*N*	SD	Min.	Max.
7–11	16.62	8	2.17	13.19	19.82
12–14	18.41	13	1.96	15.43	22.21
15–18	19.01	7	1.26	16.65	20.45
Total	18.05	28	2.04	13.19	22.21

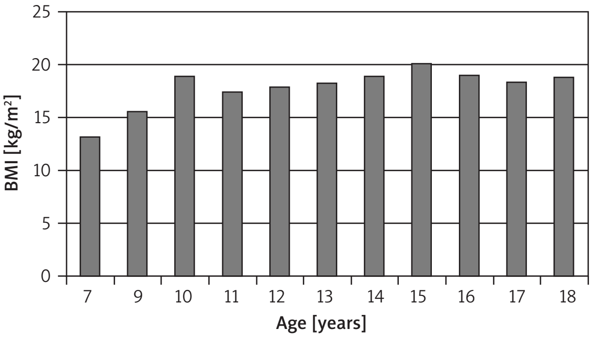

Figure 5. Body mass index and the age of the examined

Discussion

Asymmetries in the areas of the shoulders, scapulae and iliac spine are often the first symptom of scoliosis. They are closely related to the anatomical and functional conditions of the thoracic and lumbar vertebrae. One attempts to restore the distorted static balance of the body posture simultaneously in three planes (frontal, transverse and sagittal), taking into consideration the influence on the three following items: the pelvis and lumbar vertebrae, the thoracic vertebrae, and the thorax and shoulder girdle. The pelvis along with the sacral bone form the base of the spine. Each of its, even slightest, deviation in the frontal plane causes a disruption in the equilibrium in this plane and entails a lateral curvature of the spine [8]. Skolimowski *et al.* [9], in their research on pelvic functional parameters, stated that irrespectively of the type of scoliosis, the oblique pelvis type is dominant (about 50%), with the posterior and anterior superior iliac spines inclined in the same direction. An improper position of the pelvis has an impact on the angular position of the vertebrae above, that is the lumbar and thoracic vertebrae. The causes of such a state may be relaxation or contraction of the muscular apparatus, or anatomical disorders, e.g. a relative shortening of the lower limb. In lumbar scoliosis, the pelvis may be included in the lumbar curvature, meaning a three-dimensional displacement in the same direction as the lumbar vertebrae; or it can be part of the counter-curvature and be subjected to displacement in the opposite direction. In the end, distortion of the pelvis is a resultant of the three-dimensional displacement and the three-dimensional internal distortion of the pelvis. The pelvis is an osseous rim and its slight distortion is hard to detect. At times, clinically, an uneven positioning of the iliac spines can be observed, despite the lower limbs being

Table 5. Analysis of variance of BMI in terms of age

SS Effect	DF Effect	MS Effect	SS Error	DF Error	MS Error	*F*	*P*
24.41	2	12.20	88.46	25	3.53	3.45	0.05

SS – sum of squares, DF – degree of freedom, MS – mean square, F – the ratio of MS effect to MS error, p – level of significance

Table 6. Bad posture in the frontal plane and age

Bad posture in the frontal plane	Age			
	7–11	12–14	15–18	Total
Scoliotic posture	6	10	5	21
	21.43%	37.71%	17.86%	75.00%
Idiopathic scoliosis	2	3	2	7
	7.14%	10.71%	7.14%	25.00%
Total	8	13	7	28
	28.57%	46.43%	25.00%	100.00%

$\chi^2 = 0.072$, df = 2, p = 0.96

of equal length; there can also be protrusion or retraction of one of the iliac spines in the transverse plane, asymmetry in the range of movement in the hip joints, and asymmetry in the rotational positioning of the lower legs and feet. The aforementioned remarks should not be understood in an aetiological way and are not an argument for any of the postulated causes of scoliosis occurrences. Orthopaedists will not unravel the aetiology of scoliosis, however, knowledge of the pathogenesis is key to an early diagnosis and an effective treatment [2]. Asymmetrical positioning of the iliac spines, meaning the positioning of the sacral bone in connection with a slight displacement of the long axes of the two branches of pubic bones in relation to each other, which gives the image of a twisted pelvis, can sometimes be observed on the cards from tests using the moiré effect or on X-ray pictures. These changes are most often a result of a backward rotation of the left hip bone connected with a forward rotation (nutation of the upper-left side) of the sacral bone around the right axis of a diagonal drawn from the upper-right corner of the sacrum to the lower-left corner. The lower-right corner of the sacrum rotates backwards. At the same time, a counter-positioning of the right part of the ilium and of the sacrum, connected with it by the sacro-iliac joint, can be observed. The consequence of this process is a disorder of the functioning of sacro-iliac joints, which are also a sensorimotor organ participating in the formation of the

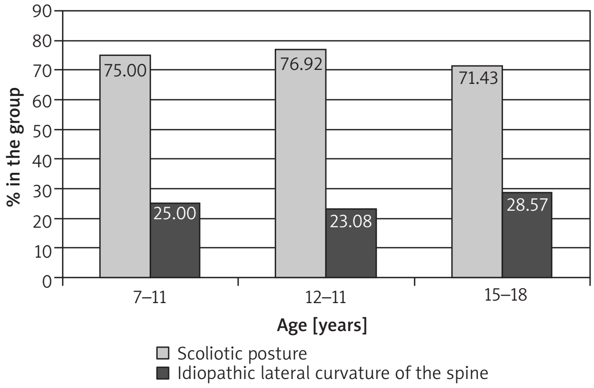

Figure 6. Bad posture in the frontal plane and the age of the examined

Table 7. Detailed parameters of body posture for the whole group

Frontal parameters of posture	*N*	*X*	Med.	Min.	Max.	*R*	SD	SKEW	*K*
ABP	28	2.61	0	0	18	18	5.04	2.072	3.520
ABL	28	6.07	5.5	0	20	20	6.17	0.750	–0.619
KLB	28	1.39	1	0	4	4	1.07	0.499	–0.135
ALP	28	2.86	1	0	10	10	3.71	1.013	–0.499
ALL	28	2.25	0	0	15	15	4.14	1.920	2.758
KNM	28	1.68	1	0	7	7	1.52	1.759	4.575
KSM	28	3.39	2.5	0	10	10	2.66	0.728	–0.319
WBM	28	99.64	101	49	106	57	10.35	–4.627	23.228
WBK	28	101.68	102	97	106	9	2.47	–0.111	–0.736
WBC	28	105.00	105	90	118	28	6.27	–0.234	0.255

Table 8. Detailed parameters of body posture in the 7–11 range

Frontal parameters of posture	*N*	*X*	Med.	Min.	Max.	*R*	SD	SKEW	*K*
ABP	8	1.00	0	0	7	7	2.45	2.722	7.500
ABL	8	4.75	6	0	12	12	3.99	0.461	0.300
KLB	8	1.00	1	0	3	3	0.93	1.440	3.500
ALP	8	3.25	2.5	0	10	10	3.65	0.857	–0.090
ALL	8	0.50	0	0	2	2	0.93	1.440	0.000
KNM	8	1.13	1	0	2	2	0.83	–0.277	–1.392
KSM	8	4.25	4	1	8	7	2.60	0.218	–1.699
WBM	8	102.13	101	99	106	7	2.80	0.611	–1.538
WBK	8	102.13	102	99	105	6	2.36	0.064	–1.730
WBC	8	105.88	106.5	97	112	15	4.49	–0.954	1.701

Table 9. Detailed parameters of body posture in the 12–14 range

Frontal parameters of posture	*N*	*X*	Med.	Min.	Max.	*R*	SD	SKEW	*K*
ABP	13	2.92	0	0	16	16	5.41	1.720	1.800
ABL	13	8.15	6	0	20	20	7.22	0.207	–1.517
KLB	13	1.69	2	0	4	4	1.11	0.289	0.481
ALP	13	1.92	0	0	10	10	3.04	1.873	3.385
ALL	13	3.23	0	0	15	15	5.25	1.458	0.768
KNM	13	1.77	1	0	7	7	1.88	1.911	4.769
KSM	13	3.15	3	0	6	6	2.23	0.252	–1.531
WBM	13	97.46	101	49	106	57	14.80	–3.404	11.975
WBK	13	101.77	102	97	106	9	2.74	–0.030	–0.957
WBC	13	103.77	102	95	114	19	5.88	0.304	–0.726

Table 10. Detailed parameters of body posture in the 15–18 range

Frontal parameters of posture	*N*	*X*	Med.	Min.	Max.	*R*	SD	SKEW	*K*
ABP	7	3.86	0	0	18	18	6.59	2.117	4.697
ABL	7	3.71	1	0	15	15	5.50	1.790	3.213
KLB	7	1.29	1	0	3	3	1.11	0.249	–0.944
ALP	7	4.14	1	0	10	10	4.88	0.373	–2.707
ALL	7	2.43	0	0	9	9	3.87	1.288	–0.297
KNM	7	2.14	2	1	4	3	1.35	0.798	–1.280
KSM	7	2.86	1	0	10	10	3.53	1.753	2.776
WBM	7	100.86	102	95	106	11	3.80	–0.431	–0.630
WBK	7	101.00	102	97	103	6	2.24	–1.127	0.312
WBC	7	106.29	106	90	118	28	8.85	–0.764	1.671

Table 11. Analysis of variance of posture parameters in age groups

Frontal parameters of posture	SS Effect	DF Effect	MS Effect	SS Error	DF Error	MS Error	*F*	*P*
ABP	32.898	2	16.449	653.78	25	26.151	0.629	0.541
ABL	109.236	2	54.618	918.62	25	36.744	1.486	0.245
KLB	2.480	2	1.240	28.2	25	1.127	1.100	0.348
ALP	24.148	2	12.074	347.28	25	13.891	0.869	0.431
ALL	37.228	2	18.614	426.02	25	17.040	1.092	0.350
KNM	4.067	2	2.033	58.04	25	2.321	0.876	0.428
KSM	8.629	2	4.314	182.05	25	7.282	0.593	0.560
WBM	121.465	2	60.732	2768.96	25	110.758	0.548	0.584
WBK	4.924	2	2.462	159.18	25	6.367	0.387	0.683
WBC	37.388	2	18.694	1024.61	25	40.984	0.456	0.638

upright posture and play their part in the coordination of the movement of upper and lower limbs [10–14]. That is why in choosing the methods of treatment for scoliotic postures and scoliosis, asymmetries occurring in the areas of the shoulder and pelvic girdles, the pelvis and the sacrum should also be taken into consideration, apart from, among others, the angle of the curvature and its location.

Conclusions

Asymmetry of the shoulders and shoulder blades was found in all of the examined. The left shoulder along with the left shoulder blade were raised more often. The right side of the pelvis was lowered in most of the examined. Posterior rotation of the left hip bone occurred more often (counter-clockwise pelvic rotation). The values of WBM, WBK and WBC asymmetry coefficients confirm the asymmetry of the shoulder and hip girdles. Analysis of variance did not show any significant relations of asymmetry of the shoulder and hip girdles and the age of the examined.

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