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The assessment of the relationships between body posture indices and the Y-Balance Test results in the adolescents

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Purpose: The purpose of this work was to assess the differences of the values of body posture indices, measured with the Moire's method, between girls and boys aged 13 and the relationships of these values with the results of the Y-Balance Test. *Methods:* The study involved a group of healthy volunteers attending junior high schools in Cracow. The group consisted of 20 girls and 35 boys. Basic somatic parameters were measured within this work: body height and weight. Body posture was assessed according to the general methodology of the Moire's technique and 14 body posture indices were obtained as a result: 6 in the sagittal plane, 1 in the axial plane and 7 in the coronal plane. Postural stability was assessed with the Y-Balance Test (YBT). *Results:* The studied girls and boys had practically the same body posture – statistical differences were found only in 3 out of 14 assessed indices measured with the Moire's technique. Scoliosis was found in as many as 51% of the subjects, however, mean values of deviations from the C7-S1 line were not large. *Conclusions:* In the group of girls, the *set of blades (below – above)* was statistically significantly correlated with the global YBT result for the right inferior extremity, and in the group of boys – *the set of the waist triangles (below – above)* was statistically significantly correlated with the global YBT results for the right and left inferior extremities.

Key words: *body posture, photogrammetric method, postural stability, Y-Balance Test*

1. Introduction

Body posture defects represent one of the biggest health problems of the contemporary society. Every year, the proportion of individuals with body postures abnormalities increases. In Poland, according to Janiszewska et al. [6], the proportion of children and adolescents aged 7–15 years with diagnosed posture defects ranges from 65% to more than 90%. The results of the presented studies, in comparison, e.g., with the results of school-age children from the Czech Republic are highly alarming. According to Kretanova et al. [8] only 38.3% of Czech pupils aged 7–15 years have a diagnosis of a posture defect.

Particular risks in the process of body posture formation occur in the periods of its instability. The early school period (at the age of 6–7 years), associated with undertaking school obligations and with a life-style change is the first of the critical posturogenesis stages. The second unfavourable stage is the adolescence period – between the age of 9–16 when the processes of growing and functional maturation are most intense.

Maintenance of the vertical body posture in a relatively stable position is a manifestation of neuromuscular coordination and is associated with continuous corrective movements, restoring the correct position of the centre of gravity over the base of support [16]. Posture and balance control is a complex mechanism

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based on interactive dynamic, sensory and motor processes [5]. It is an autonomous and involuntary process that engages reflex activities. This requires continuous cooperation of three sensor systems – of the proprioceptor, visual and vestibular ones [20]. The ease of vertical posture maintenance by humans means that postural stability is considered obvious and does not require any significant effort. The complicated mechanism and complexity of the process of control becomes manifest only when there are pathological or involutional changes or when its components are damaged.

Research studies do not show clearly whether and how postural stability correlates with the parameters describing body posture. According to Nowotny [15], decreased physical fitness related to posture defects manifests mainly as worsened sensation of body position in the space and of the mutual positions of its particular segments, lower precision of differentiation of the magnitude of the forces acting on the spine and as an altered model of body balance control in static conditions. Nowotny pointed also to the tendency to less effective counterbalance reaction after sudden throwing off balance. During his studies, he also observed that the duration of compensation movements to restore body stabilisation is longer in children with posture defects. Similar observations were made by Ostrowska and Skolimowski [18], who have proved that people with scoliosis have more pronounced body balance disturbances and need more time to regain a stable posture. Many studies have confirmed a negative effect of idiopathic scolioses on the control of postural stability and pointed to a possibility of a failure of the system regulating counterbalance reactions, postural reflexes and voluntary movements [24]. Many years ago Swedish doctors, Lidstrom et al. [11] already proved a strong correlation between balance disturbances and the angle of scoliosis, scoliosis progression rate and bone maturity level.

In the literature, besides the reports confirming the relationships between body posture and postural stability there are also publications that negate their mutual correlations. A study conducted by Kasperczyk [7] did not show any significant relationships between posture quality and marching balance. The results of a study by Wilczyński [30] also suggested the absence of any significant correlations between posture types and counterbalance reactions. Peterson et al. [19] have shown that children younger than 12 are not able to fully make use of the stimuli from the organ of sight and from the ear vestibule during their maintenance of vertical body posture. Lack of integration of these stimuli until reaching the age of 15–16 was confirmed by the results of a study by Steindl et al. [26].

Increased disturbances of body statics in adolescents as well as their consequences in adult age suggest the need for more detailed diagnostics of body posture defects of the adolescents and for evaluation of the existing therapeutic programmes. Research studies assessing the relationships between body posture and postural stability may play an important role in physiotherapy practice. Unequivocal determination of existing correlations will allow for inclusion of relevant exercises into the therapeutic process, thus, increasing the efficacy and comprehensiveness of the conducted therapy. Taking the above into consideration, the research presented in our own work seems important and up-to-date.

The purpose of this work was to assess the differences of the values of body posture indices measured with the Moire's method between girls and boys aged 13 years and the relationships of these values with the results of the Y-Balance Test.

The following research questions were formulated:

1. Are there any statistically significant differences between analogous indices assessing the body posture of girls and boys?
2. Are there any deviations from normal values of the measured body posture indices and what is their number?
3. How many of the examined girls and boys have a normal body posture, and how many of them – a disturbed one?
4. Are there any statistically significant relationships between the values of the body posture indices and global Y-Balance Test results?

2. Materials and methods

The study involved a group of 55 healthy pupils aged 13 attending junior high schools in Cracow. There were 20 girls (36.4%) and 35 boys (63.6%) among the study subjects. The detailed biometric data are presented in Table 1. The subjects regularly attended physical education lessons, 4 didactic hours per week. The examinations were performed in the morning, in September and October 2016, in a gymnasium. The examinations were non-invasive in nature and were performed with the consent of the School Management and after informed consent of the parents of the examined children was obtained. The scope of the examinations did not exceed the scope of preventive examinations of adolescents attending junior secondary schools, performed within physical education and was accordant with the Declaration of Helsinki issued by the World Medical Association [27].

Table 1. Participant characteristics

Variables	Total	Girls	Boys
	$n = 55$	$n = 20$	$n = 35$
	mean ± SD	mean ± SD	mean ± SD
Age [years]	13.2 ± 0.3	13.3 ± 0.3	13.1 ± 0.3
Height [m]	1.6 ± 0.1	1.6 ± 0.1	1.6 ± 0.1
Weight [kg]	52.9 ± 11.7	54.8 ± 9.8	51.8 ± 12.7

2.1. Measurements of somatic parameters and diagnosis of lateralisation

Basic somatic parameters were measured within this work: body height and weight. An anthropometer (Martin's type, USA) was used for the measurement of body height. The measurement was done with accuracy of 1 cm. Body weight was measured with an electronic scale (Radwag, WPT 100/200 OW), with a 0.1 kg accuracy. Diagnosis of lateralisation was performed with the step forward test [28]. Only right-footed individuals were qualified for the study.

2.2. Examination of body posture

Body posture was assessed according to the general methodology of the Moire's technique and 14 parameters determining body posture were obtained as a result (6 in the sagittal plane, 1 in the axial plane and 7 in the coronal plane) [14]. To enable photogrammetric examination, points and measurement lines with characteristic distribution pattern were marked. The system for photogrammetric body posture assessment of CQ Elektronik System was used in this study [15].

As the parameters obtained with the Moire's method are not normalised, based on the results obtained the authors of this work have proposed creation of intervals for the indices measured, both for girls and for boys, to define normal and disturbed body posture. For parameters: *Tilt of the trunk (TT), Maximum rotation (MR), Inclination of the trunk (IT), Set of shoulders (SS), Set of blades: below – above (SB: b-a), Set of blades: closer – further (SB: c-f), Difference deflection angles of the lower blade of the spine (DDALBS), Setting the waist triangles: below – above (SWT: b-a), Setting the waist triangles: narrowly – wider (SWT: n-w), Difference of the height of the anterior superior iliac spine (DHASIS) and Maximum deviation from the straight line of the spine C7–S1 (MDFSLS C7-S1)* the interval ± SD is considered the normal value, corresponding to the acceptable variability of results in a healthy population. This interval included dispersion of results from the "0" value corresponding to the ideal posture within the listed variables. The calculations were done on absolute values. When a parameter value exceeding the predefined range was obtained for the examined individual it was conventionally called "deviation from the normal value" indicating disturbed body posture. For the other parameters: *Lumbar lordosis angle (LLA), Thoracic kyphosis angle (TKA), Depth of thoracic kyphosis (DTK), Depth of lumbar lordosis (DLL)* the values defining a normal posture were determined by calculating the arithmetical mean and the interval ± SD. As a result, the range of acceptable variability of values was obtained. Similarly to the previous case, the results outside the range presented above were deemed "deviations from the normal value" reflecting a disturbed posture. For the needs of further analysis, the subjects were divided into two subgroups based on the numbers of "deviations from the normal value". The first subgroup included subjects with 0 to 3 deviations (a normal body posture), and the second one – the subjects with 4 and more deviations (a disturbed body posture).

2.3. Examination of postural stability

The assessment of postural stability was performed with the Y-Balance Test (YBT) [22]. According to the instructions of the YBT creators, a specially constructed diagnostic tool, so called Y-Balance Test Kit was used for measurements. A measurement procedure was defined in accordance with Plisky et al. [21] guidelines. Three trials were done for each lower extremity and for each movement direction. If the test was started from the left lower extremity, the subject performed the first three trials standing on the left lower extremity and reaching forward (anterior reach) with the right lower extremity. In the next three trials, the right lower extremity was the stance extremity and the left one – the reach extremity, with the same reach direction. This trial mode was repeated with measurements for the posteromedial and posterolateral directions. The measurements of the distance of the indicator moved from the central platform were done with accuracy of 0.5 cm. The trial was deemed successful when the subject was able to return to the starting position after he/she had performed the movement. After the test was completed, relative lengths of both lower extremities were measured with accuracy to 0.5 cm. During the analysis of the results, the highest reach result achieved in each direction during unilateral stance was calculated for the length of the stance extremity, according to the following formula:

$$MAXD\ (\%) = [EL / LL] \times 100 \quad (1)$$

Composite YBT score was also calculated for each subject, using the following formula:

$$YBT\text{-}CS\ (\%) = [(AN + PM + PL)/(LL \times 3)] \times 100 \quad (2)$$

where: *MAXD* (%) – the maximum reach distance in one direction in %, *EL* – distance of reach in one direction, *LL* – relative length of the extremity, *YBT-CS* (%) – *YBT* composite reach score, *AN* – anterior reach, *PM* – posteromedial reach, *PL* – posterolateral reach.

2.4. Statistical methods

The statistical analysis was done with the use of the IBM SPSS Statistics software. Differences between body posture indices of girls and boys, as well as these of global YBT results were verified. Statistical significance level was set at $p \leq 0.05$. At the initial stage of analysis, distribution of the examined variables was calculated with the use of Shapiro–Wilk W-test. Basic subjects characteristics were presented using descriptive statistics. Arithmetical means with standard deviation and median values were calculated for numerical variables and numerical amounts [*n*] in particular categories – for nominal variables. The relationships between body posture parameters and YBT results were examined based on correlation tests. As the distributions found were not normal ones, Spearman rank of correlation was used for relationship calculations. To verify the significance of differences between mean values of the examined variable between both sexes, the Mann–Whitney U-test was used.

3. Results

3.1. Analysis of body posture indices measured with the Moire's method

Table 2 presents characteristics of the measured body posture indices.

Table 3 presents the results of a non-parametric Mann–Whitney U-test, performed to verify the hypothesis about insignificance of the differences between the girls' and the boys' body posture indices. The girls were found to differ statistically significantly from the boys only with respect to three variables: *lumbar lordosis angle, setting of blades (below – above)* and *setting of the waist triangles (narrowly – wider).*

Table 2. Mean values, standard deviations and median values of body posture indices of all subjects, girls and boys

Parameter	Total	Girls	Boys
	n = 55	*n* = 20	*n* = 35
	mean ± SD; median	mean ± SD; median	mean ± SD; median
TT [deg]	6.6 ± 4.8; 5.4	5.5 ± 4.8; 4.9	7.3 ± 4.7; 7.1
LLA [deg]	158.9 ± 8.7; 158.5	154.6 ± 8.5; 155.4	161.4 ± 7.9; 161.5
TKA [deg]	159.7 ± 13.3; 160.1	156.7 ± 16.7; 161.1	161.4 ± 10.9; 159.8
DTK [mm]	24.4 ± 16.2; 24.0	23.6 ± 17.6; 17.0	24.9 ± 15.5; 28.0
DLL [mm]	30.3 ± 15.6; 32.0	29.0 ± 17.3; 34.0	31.0 ± 14.8; 30.0
MR [deg]	9.0 ± 6.4; 7.9	8.5 ± 6.7; 7.3	9.2 ± 6.3; 8.3
IT [deg]	1.4 ± 1.3; 1.0	1.4 ± 1.5; 1.0	1.4 ± 1.3; 0.9
SS [mm]	5.4 ± 5.8; 4.0	6.7 ± 7.8; 5.5	4.7 ± 4.3; 4.0
SB: b-a [mm]	7.3 ± 7.9; 5.0	6.5 ± 10.7; 2.0	7.7 ± 5.9; 6.0
SB: c-f [mm]	9.5 ± 8.8; 6.0	9.7 ± 10.1; 6.0	9.5 ± 8.2; 6.0
DDALBS [mm]	9.3 ± 6.0; 9.0	9.5 ± 4.7; 9.0	9.1 ± 6.7; 9.0
SWT: b-a [mm]	7.1 ± 5.7; 6.0	9.3 ± 6.5; 9.0	5.8 ± 4.9; 5.0
SWT: n-w [mm]	12.3 ± 8.5; 11.0	15.9 ± 6.9; 15.5	10.2 ± 8.7; 9.0
DHASIS [mm]	2.0 ± 2.4; 1.0	2.4 ± 2.5; 2.0	1.8 ± 2.3; 1.0
MDFSLS C7-S1 [mm]	4.7 ± 1.9; 5.0	4.7 ± 2.2; 5.0	4.8 ± 1.8; 5.0

Table 3. Comparative analysis of girls and boys for body posture parameters performed with the Mann–Whitney U-test

Parameter	Tested value[a]	
	U Mann–Whitney	Asymptotic significance (two-sided)
TT [deg]	268.0	0.151
LLA [deg]	185.5	0.004*
TKA [deg]	337.5	0.827
DTK [mm]	329.0	0.713
DLL [mm]	329.0	0.713
MR [deg]	340.5	0.868
IT [deg]	350.0	1.000
SS [mm]	318.0	0.573
SB: b-a [mm]	228.0	0.032*
SB: c-f [mm]	334.0	0.779
DDALBS [mm]	316.0	0.551
SWT: b-a [mm]	244.0	0.063
SWT: n-w [mm]	182.0	0.003*
DHASIS [mm]	296.0	0.325
MDFSLS C7-S1 [mm]	332.5	0.756

a – grouping variable: sex, * $p < 0.05$.

Table 4. The number of subjects with "deviations from normal values" for each of the assessed body posture indices

Parameter	Total	Girls	Boys
	n = 55	*n* = 20	*n* = 35
TT [deg]	19	5	14
LLA [deg]	13	5	8
TKA [deg]	6	3	3
DTK [mm]	18	3	15
DLL [mm]	19	6	13
MR [deg]	21	7	14
IT [deg]	19	7	12
SS [mm]	24	9	15
SB: b-a [mm]	23	6	17
SB: c-f [mm]	21	7	14
DDALBS [mm]	25	10	15
SWT: b-a [mm]	25	10	15
SWT: n-w [mm]	22	9	13
DHASIS [mm]	21	7	14
MDFSLS C7-S1 [mm]	28	11	17

n – number of examined subjects.

Table 4 presents a summary of the numbers of subjects with "deviations from normal values" for each of the assessed body posture indices. It was found that as many as 28 out of 55 examined subject (11 girls and 17 boys) exceeded the *maximum deviation from the straight line of the spine C7–S1*. Large numbers of deviations were also found with respect to the *difference of deflection angles of the lower blade of the spine* (25 subjects), *set of shoulders* (24 subjects) and *setting of the waist triangles (below – above)* (25 subjects). In the group of girls deviations of the *difference of deflection angles of the lower blade of the spine* and *setting of the waist triangles (below – above) predominated* (10). Less frequently, only in 9 of them, deviations with respect to *set of shoulders* and *setting the waist triangles (narrowly – wider)* were observed. Among the boys, besides the *maximum deviation from the straight line of the spine C7–S1, set of blades (below – above)* was the most commonly noted deviation (17).

Table 5 presents numerical summary of the subjects with deviations from normal values in each group. Only 8 from among all subjects had 3 or less deviations, and in as many as 47 subjects 4 or more deviations were found. Only 3 out of 20 girls did not have more than 3 deviations. Similarly, only 5 of 35 boys were in the subgroup with 0 to 3 deviations; the other boys had 4 and more deviations.

Table 5. The number of subjects with "deviations from normal values" of body posture indices

Parameter	Total	Girls	Boys
	n = 55	*n* = 20	*n* = 35
0–3 deviations	8	3	5
4 and more deviations	47	17	30

n – number of examined subjects.

3.2. Analysis of the examination of postural stability

Tables 6 and 7 present a summary of global YBT result for the left and right lower extremity obtained in the groups of girls and boys.

Table 6. A summary of the global YBT result in the group of girls

Global YBT result [%]	Mean ± SD	Min	Max
The left lower extremity	98.0 ± 8.8	80	114
The right lower extremity	99.9 ± 6.5	84	115

Table 7. A summary of the global YBT result in the group of boys

Global YBT result [%]	Mean ± SD	Min	Max
The left lower extremity	93.9 ± 10.2	80	125
The right lower extremity	94.8 ± 11.9	82	130

3.3. Analysis of the relationships of body posture indices with global YBT results

Tables 8 and 9 present Spearman's rank correlation coefficients between body posture parameter values and global YBT results both for girl and for boys. Observation in the group of girls showed that only *setting of blades (below – above)* was statistically significantly correlated with the global YBT result for the right lower extremity ($p = 0.014$); this was a correlation of moderate strength $r = 0.54$. The analysis performed in the group of boys showed a statistically

Table 8. Spearman's rank correlation coefficient in the group of girls

Parameter	Spearman's rho correlations				
	YBT L [%]		YBT R [%]		*n*
	Correlation coefficient	Statistical significance (two-sided)	Correlation coefficient	Statistical significance (two-sided)	
TT [deg]	0.24	0.300	0.14	0.564	20
LLA [deg]	–0.01	0.972	–0.02	0.940	20
TKA [deg]	–0.07	0.764	0.23	0.328	20
DTK [mm]	–0.05	0.842	–0.09	0.704	20
DLL [mm]	–0.03	0.894	–0.16	0.500	20
MR [deg]	–0.24	0.308	0.06	0.798	20
IT [deg]	–0.27	0.252	–0.07	0.756	20
SS [mm]	–0.29	0.212	–0.30	0.200	20
SB: b-a [mm]	0.43	0.057	0.54	0.014*	20
SB: c-f [mm]	–0.18	0.437	0.10	0.669	20
DDALBS [mm]	–0.24	0.301	–0.28	0.235	20
SWT: b-a [mm]	–0.05	0.825	–0.06	0.788	20
SWT: n-w [mm]	0.28	0.237	0.18	0.455	20
DHASIS [mm]	–0.14	0.564	0.00	0.999	20
MDFSLS C7-S1 [mm]	–0.13	0.596	–0.06	0.819	20

* $p < 0.05$.
Legend: *YBT L – YBT Left, YBT R – YBT Right*.

Table 9. Spearman's rank correlation coefficient in the group of boys

Parameter	Spearman's rho correlations				
	YBT L [%]		YBT R [%]		*n*
	Correlation coefficient	Statistical significance (two-sided)	Correlation coefficient	Statistical significance (two-sided)	
TT [deg]	0.11	0.540	0.23	0.191	35
LLA [deg]	0.88	0.617	0.12	0.496	35
TKA [deg]	–0.01	0.996	–0.00	0.990	35
DTK [mm]	0.20	0.248	0.25	0.144	35
DLL [mm]	–0.05	0.772	0.14	0.415	35
MR [deg]	0.09	0.621	0.02	0.915	35
IT [deg]	0.10	0.571	–0.06	0.730	35
SS [mm]	0.14	0.418	–0.07	0.684	35
SB: b-a [mm]	–0.04	0.837	–0.10	0.582	35
SB: c-f [mm]	0.32	0.060	0.21	0.233	35
DDALBS [mm]	–0.06	0.753	–0.13	0.458	35
SWT: b-a [mm]	–0.56	0.000**	–0.41	0.014*	35
SWT: n-w [mm]	0.22	0.197	0.05	0.781	35
DHASIS [mm]	0.30	0.078	0.00	0.982	35
MDFSLS C7-S1 [mm]	–0.04	0.802	–0.19	0.272	35

* $p < 0.05$.
Legend: *YBT L – YBT Left, YBT R – YBT* Right.

significant correlation between *setting of the waist triangles (below – above)* and global YBT results both for the left and for the right lower extremities ($p = 0.000$ and $p = 0.014$, respectively); the observed variables were negatively correlated in both cases, and the strength of their relationships was a moderate one ($r = –0.56$ and $r = –0.41$, respectively).

4. Discussion

In spite of ongoing health programmes and preventive actions, the condition of body posture of young people remains unsatisfactory. In scientific publications concerning body posture, besides the causes of defects' development, much attention is paid to appropriate diagnosis of these defects.

The girls and the boys examined within this work had practically the same body posture – statistical differences were found only in 3 out of 14 assessed indices measured with the Moire's technique (1 in the sagittal plane and 2 in the coronal plane). Scoliosis was found in as many as 51% of the subjects, however mean values of deviations from the C7-S1 line were not large. This fact translated into occurrence of other asymmetries within the trunk: in the setting of the shoulder blades, shoulders and waist triangles. These unfavourable changes cannot be ignored – a thorough diagnostics should be continuously carried out and any possible changes of the previously mentioned deformities should be monitored [1].

Research studies do not show clearly whether and how postural stability correlates with the body posture. Literature on the subject includes several reports, some negating and other confirming the existence of these mutual relationships [17]. In his studies, Ludwig [13] did not note any significant effect of body posture defects of the adolescents on worsening of postural stability measured during a 20-second examination on a specially prepared balancing platform. The author proposed that correction of body posture was independent from the training improving dynamic balance of young individuals. Lee [10] has found in his studies that in young individuals a posture with head protrusion has a bigger effect on the control of the static balance than on that of the dynamic one, both with open and shut eyes. The results of the studies of marching balance performed by Kasperczyk [7] did not show any relationship between postural balance and body posture, either. Neither any significant differences in the results of balance evaluation in girls and boys were found. A work by Byl and Gray [3] has proved that even with marked asymmetry of body posture there are only minor deviations of the centre of gravity projection. However, contrary data were provided by the results of a study by Wilczyński [30]. The author has shown that children with a scoliosis exceeding 10° have worse visual-motor coordination and worse balancing reactions, both with open and shut eyes.

A study by Walaszek [29] conducted in a group of 14-year-old girls showed that the result of the walking (dynamic) balance test performed after Kasperczyk [7] correlated in four cases with body posture indices measured with Moire's method: a reduction of the lumbar lordosis and lowered left shoulder resulted in balance improvement. In the other two cases balance worsening occurred along with an increased depth of the thoracic kyphosis and with and increased depth of the lumbar lordosis. The results of our own work did not suggest any relationships of the above parameters with the YBT results, both in female and in male subjects. There was only a moderate relationship between the global YBT result for the right lower extremity and the *setting of blades (below – above).* A minor increase in shoulder blade asymmetry in the coronal plane favoured an improvement of dynamic balance measured for the right lower extremity. This may be the effect of compensatory mechanisms worked out in these subjects aiming at a better control of body posture in case of the occurrence of the above asymmetry. A report by Rykała et al. [23] has not shown any significant relationships between the set of shoulder blades and postural stability. According to these authors, a minor asymmetry of the setting of blades has no effect on the obtained stabilometric parameters. Also Sipko et al. [25] observed no relationship between the size of the shifts of the stabilogram curve and morphological asymmetry of the trunk.

Correlation analysis in the work of Lizis and Walaszek [12] showed that taller boys are more frequently at risk of asymmetry of pelvis position and – probably resulting from this fact – development of scoliosis. This analysis also showed that boys with round back accompanied by waist triangle asymmetry have worse balance than boys without body posture disturbances. Similar results were obtained in this work. In boys, a statistically significant correlation of the *setting of the waist triangles (below – above)* with global YBT results both for the left and for the right lower extremity was noted – increased asymmetry of the setting of the waist triangles caused worsening of the results of dynamic balance measured with YBT.

In spite of many "excursions from the normal values" of the indices assessing body posture (as many as 47 girls and boys out of all 55 subjects had 4 and more deviations) mean values of global YBT results ranged in the entire study group from 93.9% (for the left extremity in boys) to 99.9% (for the right extremity in girls). These were very good results, and as American scientists, Butler et al. [2] have proved – results that suggest a very low risk of injuries. These scientists estimated limits of better and worse postural stability based on global results obtained in the YBT test. Global YBT results for both extremities that are lower than 89.6% point to a higher risk of motor system injuries (a 3.5-fold increase). The results exceeding this value carry a lower risk of injuries. Based on the above, a low effect of body posture disturbances on postural stability of the examined group may be presumed. The explanation of this situation may be the fact that posture disturbances of the examined girls and boys were numerous but of a minor severity.

The mechanisms of body balance control during quiet standing may vary even in a healthy population of the same sex, of the same age and with similar anthropometric parameters. The complex process of balance regulation in humans and differentiated compensatory abilities of particular subjects may interfere with the obtained results. The movements correcting the change of the position of the centre of gravity involve the head, the hips and the upper and lower extremities. Taking this into consideration, examination of asymmetry signs only within the trunk does not give a complete picture of the changes occurring during the process of balance maintenance. An additional obstacle is the limited number of publications that allow to compare the results and absence of normal ranges for these parameters [4], [9]. This suggests a necessity of further research studies.

5. Conclusions

There was a statistically significant difference between the body posture of girls and boys with respect to three parameters: *lumbar lordosis angle, setting of the waist triangles (below – above)* and *setting of the waist triangles (narrowly – wider)*. In the examined group, only 8 out of 55 subjects had no more than 3 deviations from normal body posture parameters and 47 of them had 4 and more deviations. In the group of girls *setting of blades (below – above)* was statistically significantly correlated with global YBT result for the right lower extremity. In the group of boys *setting of the waist triangles (below – above)* was statistically significantly correlated with global YBT result for the right and left lower extremities.

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