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Sexual dimorphism of the frequency of significant correlations between the characteristics of body trunk and feet in children aged 4 to 6 years

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Abstract

Introduction. Relatively few publications have concerned characteristics of body trunk and feet. It is generally suggested that correlations exist between the characteristics of the developing foot and the spinal column.

Materials and methods. The examinations conducted in a group of children aged 4 to 6 years allowed for recording 2988 observations, including 1482 girls and 1506 boys, and values of 87 characteristics that described body trunk and feet. The test stand for the measurement of the selected parameters using the photogrammetric method consisted of a personal computer, software, screen and printer, and a projection-reception device with a camera.

Conclusion

1. The general number of body trunk characteristics having significant correlations with feet parameters in females was slightly higher. The number of relationships in sagittal and frontal planes was the same in both sexes. The characteristics that differentiated males from females were found mainly in transverse and frontal planes.

2. The number of feet characteristics that most often showed significant correlations with body trunk parameters was higher in girls than in boys. These were mainly characteristics concerning width and length, longitudinal arch and disorders in the position of the feet. The characteristics that differentiated boys described only the longitudinal arch of the feet.

Key words: relationships, dimorphism, characteristics of body posture, feet, sex

1. **Introduction**

The issue of sexual dimorphism in the field of somatic traits has occurred in numerous publications and seems to be obvious, well-described and undisputed [1-10]. However, there have been very few publications regarding the impact and correlations of body trunk and foot parameters. Steinmetz [11] assumes there is interdependence between the type of the forming foot and the shape of the spine. The suggestion that if the spinal traits can be corrected by modifying the foot parameters, the foot parameters can be influenced by changing the spinal characteristics, raises a number of objections. However, the results of the studies presented below at least theoretically allow such a possibility. Steinmetz also emphasizes legitimacy of wearing corrective footwear since a correctly positioned foot in a special footwear can cause spinal deformation which is consistent with the views expressed by the author of this paper. The pilot studies by Drzał-Grabiec and Snela [12] in the population of 7-9-year-old girls and boys allowed to find relationships between the longitudinal arch of the right and left foot, measured with Clarke's angle, and length parameters describing body posture. According to the research there was a significant correlation between the longitudinal arch of both feet, measured using Clarke's angle and the spine height between points C_7 and S_1. This dependence was confirmed when considering the division into subgroups of boys and girls as well as age subgroups. As far as age groups are concerned, a significant correlation was observed only in the group of 9-year-olds.

The purpose of the study was to show sexual differences in the incidence of significant relationships concerning selected parameters of body trunk and feet in the group of 4-6-year-old children.

2. **Material and methods**

The studies conducted in the Warmińsko-Mazurski Voivodeship in 2000-2003 enabled to record 2,988 observations including 1,482 girls and 1,506 boys. Body posture was assessed by means of the photogrammetric method with regard to generally adopted principles [13]. The statistical analysis covered 87 angular and linear parameters of the spine, pelvis, trunk and feet in the sagittal, frontal and transverse planes, in particular age and environment categories, Table 1. The empirical data were the quantitative and qualitative characteristics (gender, domicile, etc.). The conducted calculations covering the values of position statistics (arithmetic mean, quartiles), the dispersion parameter (standard deviation) and symmetry indicators (asymmetry and concentration indicators) provided a full view of the distribution of the studied features considering gender, environment and age ranges. The correlations and their significance were assessed using p-value and frequency expressed in percentage. Due to editorial requirements related to article constraints, the detailed description, the author deliberately did not include a full statistical analysis of the findings, citing only partial results ensuing from the subject of the paper.

The fundamental assumption of the study was to always assess the habitual posture as a relatively constant individual characteristic of a human being. This posture reflected an individual emotional, psychical and social condition of the subject. Moreover, the posture provided the most reliable description of the subject's silhouette at a given time and in a place. The conducted diagnostics did not determine whether an individual's posture was correct or not, it only identified the condition of its ontogenetic development. Objectified and comparable test results were able to ensure that the postural parameters adopted for the analysis were recorded with possible to determine compensations. The combined assessment of the trunk and feet allowed to objectively determine the quality of the postural model applied in a given environment, gender and age category. The measuring instrument used in the study determined several tens of parameters describing body posture, Table 1. Obtaining the spatial picture was possible thanks to displaying the line of strictly defined parameters on a teenager's back and feet. The lines falling on the skin of a child got distorted depending on the configuration of the surface. The applied lens ensured that the imaging of a subject could be received by a special optical system with a camera, then transmitted to the computer monitor. The distortions of the line imaging recorded in the computer memory were processed

through a numerical algorithm on the topographic map of the investigated surface. When conducting the study, one should be aware of the fact that the taken photo records an image of the silhouette displayed on a child's skin [13].

Tab. 1. Characteristics of body trunk and feet

Body trunk parameters

No.	Symbol	Parameters		
		Unit	Name	Description
Sagittal plane				
1	Alfa	degrees	Inclination of lumbo-sacral region	
2	Beta	degree	Inclination of thoracolumbar region	
3	Gamma	degree	Inclination of upper thoracic region	
4	DCK	mm	Total length of the spine	Distance between C_7 and S_1, measured in vertical axis
5	KPT	degree	Angle of extension	Defined as a deviation of the C_7-S_1 line from vertical position (backwards)
6	KPT -	degree	Angle of body bent	Defined as a deviation of the C_7-S_1 line from vertical position (forwards)
7	DKP	mm	Thoracic kyphosis length	Distance between LL and C_7
8	KKP	degrees	Thoracic kyphosis angle	KKP = 180 – (Beta+Gamma)
9	RKP	mm	Thoracic kyphosis height	Distance between points C_7 and PL
10	GKP	mm	Thoracic kyphosis depth	Distance measured horizontally between the vertical lines passing through points PL and KP
11	DLL	mm	Lumbar lordosis length	Distance measured between points S1 and KP
12	KLL	degree	Angle of lumbar lordosis	KLL = 180 – (Alfa + Beta)
13	RLL	mm	Lumbar lordosis height	Distance between points S1 and PL
14	GLL -	mm	Lumbar lordosis depth	Distance measured horizontally between the vertical lines passing through points PL and LL
Frontal plane				
15	KNT -	degree	Angle of body bent to the side	Defined as deviation of the C_7-S_1 line from the vertical axis to the left

16	KNT	degree		Defined as deviation of the C_7-S_1 line from the vertical axis to the right
17	LBW -	mm	Right shoulder up	Distance measured vertically between horizontal lines passing through points B2 and B4
18	LBW	mm	Left shoulder higher	
19	KLB	degree	Shoulder line angle, right shoulder up	Angle between the horizontal line and the straight line passing through points B2 and B4
20	KLB –	degrees	Shoulder line angle, left shoulder up	
21	LŁW	mm	Left scapula up	Distance measured vertically between horizontal lines passing through points Ł1 and Łp
22	LŁW	mm	Right scapula up	
23	UL	degree	Angle of scapula line, right scapula up	Angle between the horizontal line and the straight line passing through points Ł1 and Łp
24	UL -	degree	Angle of scapula line, left scapula up	
25	OL	mm	Lower angle of left scapula more distant	Difference of the distance of lower angles of the scapula from the line of spinous processes measured horizontally along the lines passing through points Ł1 and Łp
26	OL -	mm	Lower angle of right scapula more distant	
27	TT	mm	Left waist triangle up	Difference of the distance measured vertically between points T1 and T2, T3 and T4.
28	TT –	mm	Right waist triangle up	
29	TS	mm	Left waist triangle wider	Difference of the distance measured horizontally between straight lines passing through points T1 and T2, T3 and T4
30	TS -	mm	Right waist triangle wider	
31	KNM	degree	Pelvis tilt, right ilium up	Angle between the horizontal line and the straight line passing through points M1 and Mp
32	KNM -	degree	Pelvis tilt, left ilium up	

33	UK	mm	Maximum inclination of the spinous process to the right	Maximal deviation of the spinous process from the line from S_1. The distance is measured in horizontal line.
34	UK -	mm	Maximum inclination of the spinous process to the left.	
35	NK	_	Number of the vertebra maximally distanced to the left or to the right	Number of the vertebra most distanced to the left or to the right in the asymmetric line of the spinous process, counting as 1 the first cervical vertebra (C1). If the arithmetic mean takes the value e.g. from 12.0 to 12.5, it is Th_5, if from 12.6 to 12.9 it is Th_6.
Transverse plane				
36	ŁB -	mm	Lower angle of the right scapula more convex	Difference of the distance of lower scapula angles from the surface of the back
37	ŁB	mm	Lower angle of the scapula more convex	
38	UB –	degree	Angle of projection line of lower scapula angles, the left one more convex	Difference in the angles UB1 – UB2. Angle UB2 between: the line passing through point Łl and at the same time perpendicular to the camera axis and the straight line passing through points Łl and Łp. Angle UB1 between the line passing through point Łp and perpendicular to the camera axis and the straight line passing through points Łp and Łl.
39	UB	degree	Angle of projection line of lower scapula angles, the right one more convex	
40	KSM	degree	Pelvis rotated to the right	Angle between the line passing through point M1 and perpendicular to the camera axis and the straight line passing through points M1 and MP
41	KSM -	degree	Pelvis rotated to the left	Angle between the line passing through point Mp and perpendicular to the camera axis and the straight line passing through points Ml and MP

Source: author's own research

3. **Findings**

The analysis of the findings headed in two directions. The first one was to provide an answer to the question: how often and which body trunk parameters most frequently revealed a significant correlation with feet parameters within sexual dimorphism? The second one was to

give an answer to the question: which parameters of the feet most often significantly correlated with the parameters of body trunk also within sexual dimorphism?

The analysis of the study results in terms of sexual dimorphism of body trunk parameters that most frequently differentiated the relationships with feet parameters revealed that among girls these were the values of the following parameters: the angle, height and depth of lumbar lordosis (KLL, RLL, GLL), angle of body trunk bent to the left side in the frontal plane (KNT-), angle of body bent to side in the sagittal plane (KPT-), asymmetry of waist triangles height with the right triangle up (TT-), asymmetry of the distance of lower angles from the spinous process with the angle of the left scapula being more distanced (OL), maximum inclination of one spinous process to the left (UK-). Among boys, these characteristics included: height of thoracic kyphosis (RKP), angle of body trunk bent to the right side in the frontal plane (KNT), asymmetry of the projection line of lower scapula angles with the left one more convex (UB), angle of pelvis rotated to the right (KSM), number of the vertebrae maximally distanced to the left from the spinous process (NK-), Table 2, Figure 1.

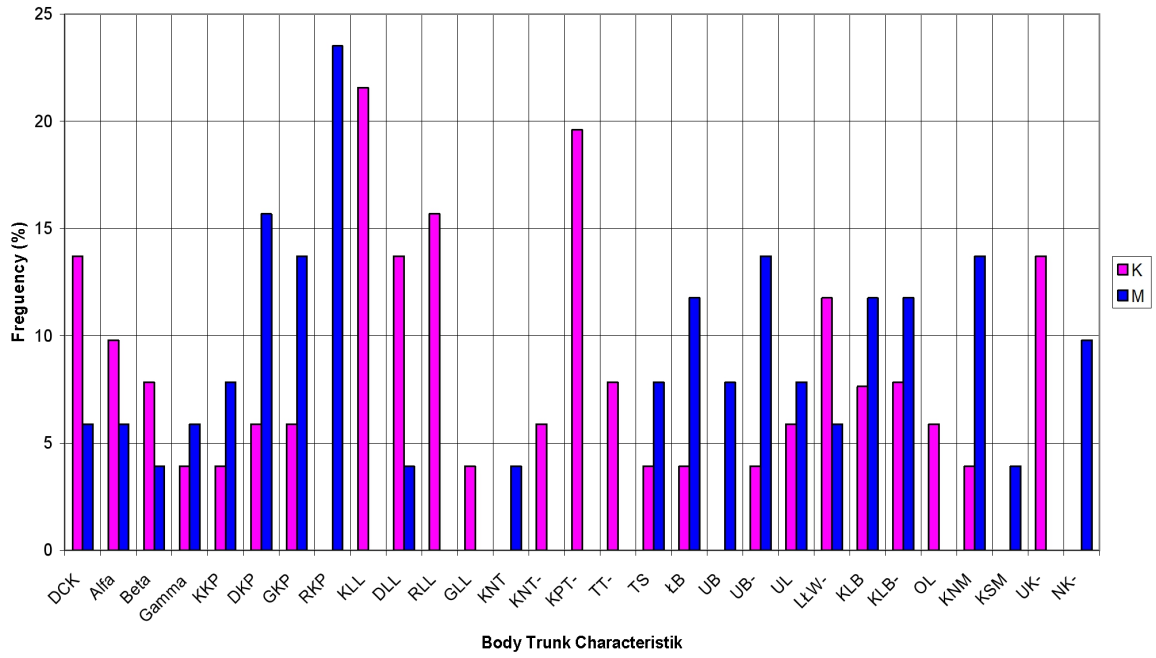
Tab. 2. Sexual dimorphism of the frequency of significant correlations between body trunk and feet characteristics

Parameter	Gender		Parameter	Gender	
	K	M		K	M
DCK	13.72	5.88	KPT-	19.6	0.0
Alfa	9.8	5.88	TT-	7.84	0.0
Beta	7.84	3.92	TS	3.92	7.84
Gamma	3.92	7.84	ŁB	3.92	11.76
KKP	3.92	7.84	UB	0.0	7.84
RKP	0.0	23.52	UB-	3.92	13.72
DKP	5.88	15.68	UL	5.88	7.84
GKP	5.88	13.72	LŁW	11,76	5,88
KLL	21.56	0.0	KLB	7,64	11,76
DLL	13.72	3.92	KLB-	7,84	11,76
RLL	15.68	0.0	OL	5,88	0,0
GLL	3.92	0.0	KNM	3,92	13,72
KNT	0.0	3.92	KSM	0,0	3,92
KNT-	5.88	0.0	UK-	13,72	0,0
			NK	0.0	9.8

Source: author's own research

K – women, M - man

Fig. 1. Sexual dimorophism of the frequency of signification correlatuins between body trunk and characteristics of feet children aged 4 to 6 years from both environments (n) K=1482, M=1506



K – women, M - man

The analysis of the study results with regard to sexual dimorphism, concerning feet parameters with which body trunk parameters correlated most frequently, showed the following parameters in girls: width of both feet (SZP, SZL), length of the left foot (DLL), valgus angle of the fifth toe in the right foot (BetaPp), and of the Plantar surface of left foot (PSL), height and length of the first arch in the right foot (WP1, DP1), width of the first and fifth longitudinal arch of the left foot (SL1, SL5). As regards boys, these were the values of such parameters as height of the second and third longitudinal arch in the right foot (WP2, WP3), width of the third and fourth arch in the right foot (SP3, SP4), height of the fourth and length of the fifth arch (WL4, DL5) and width of the third arch in the left foot (SL3), Table 3, Fig. 2.

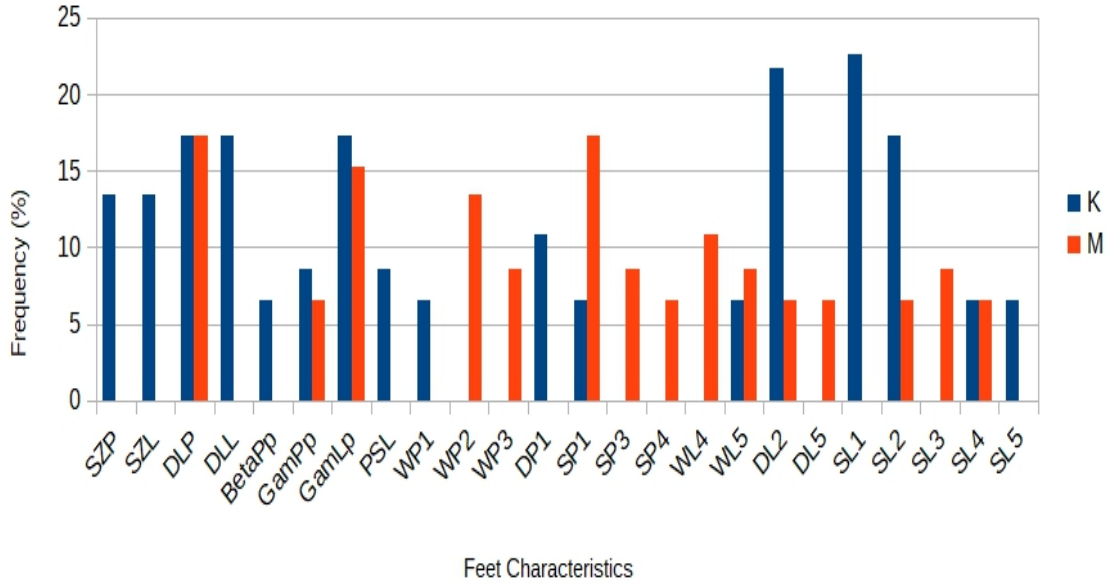
Tab. 3. Sexual dimorphism of feet characteristics which revealed the most significant correlations with body trunk characteristics

Parameter	Gender		Parameter	Gender	
	K	M		K	M
SZP	13.4	0.0	SP1	6.5	17.3
SZL	13.4	0.0	SP3	0.0	8.6
DLP	17.3	17.3	SP4	0.0	6.5
DLL	17.3	0.0	WL4	0.0	10.8
BetaPp	6.5	0.0	WL5	6.5	8.6
GamPp	8.6	6.5	DL2	21.7	6.5
GamLp	17.3	15.2	DL5	0.0	6.5
PSL	8.6	0.0	SL1	22.6	0.0
WP1	6.5	0.0	SL2	17.3	6.5
WP2	0.0	13.4	SL3	0.0	8.6
WP3	0.0	8.6	SL4	6.5	6.5
DP1	10.8	0.0	SL5	6.5	0.0

Source: author's own research

K – women, M - man

Fig. 2 Sexual dimorphism of the characteristics of feet with the most frequent correlations with body trunk in children aged 4 to 6 years from both environments (n) K = 1482, M -= 1506



K – women, M - man

The statistical analysis has shown a number of dependencies significant to the correction of postural statics disorders. When designing the correction procedure it is necessary to consider the above-shown correlations not only between the values of feet parameters and the trunk-pelvis complex, but also between the trunk-pelvis complex and feet as well as body weight and height revealed in other studies [22-25]. It should be also emphasized that the above-presented correlations should not be interpreted uncritically despite clear results of the statistical analysis as what logical impact can be exerted by the depth and height of thoracic kyphosis on the varus angle of the 5th toe?

4. **Conclusions**

1. The general number of body trunk parameters that significantly correlated with feet parameters was slightly bigger in females. The number of dependencies regarding sagittal and frontal parameters was the same in both female and male subjects. The traits that differentiated males from females mainly concerned sagittal and frontal planes.
2. The number of feet characteristics that most often showed significant correlations with body trunk parameters was higher in girls than in boys. These were mainly characteristics concerning width and length, longitudinal arch and disorders in the

position of toes. The characteristics that differentiated boys described only the longitudinal arch of the feet.

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