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Environmental dimorphism of the incidence of significant correlations between feet and body trunk parameters among 4-6-year-old children

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Key words: correlations, dimorphism, parameters of body posture, feet, environment

Abstract

Introduction. The issue of sexual and environmental dimorphism within the scope of somatic characteristics is discussed in numerous publications. Sexual dimorphism is obvious, well-described and undisputed. There are relatively few publications concerning statodynamic correlations between the parameters of feet and hip zone.

Material and method. The study conducted with the group of children aged 4 to 6 years enabled to record 2,988 observations including 1,551 in the urban environment and 1,437 in the rural environment with regard to the measurement of the 87 parameters describing trunk and feet. The station for measurement of the selected parameters using the photogrammetric method consisted of a computer, a card, software, a display monitor, a printer and a projection-reception device with a camera.

Conclusions

1. The number of foot parameters revealing significant correlations with trunk parameters and differentiating both environments is the same. Yet, in the rural

environment the correlation with trunk parameters is slightly higher. The parameters differentiating the rural environment are the features describing the longitudinal arch and the ones relating to the urban environment are describing the morphological characteristics and disorders of the toe position.

2. The number of trunk parameters with which the foot parameters significantly correlate is considerably higher in the individuals from the urban environment and this correlation is more common. The number of sagittal parameters is the biggest, followed by the number of frontal parameters and the smallest number of transverse parameters.

1. Introduction

The issue of sexual and environmental dimorphism within the scope of somatic characteristics is discussed in numerous publications [1-6]. Sexual dimorphism is obvious, well-described and undisputed. There are relatively few publications concerning statodynamic correlations between the parameters of feet and hip zone.

This problem has been investigated by Mięsowicz [15], Drzał-Grabiec, Snela [16], Mrozkowiak, Sokołowski, Jazdończyk [17, 18].

Yaser and Kasperczyk, while studying the relationships between the height of longitudinal medial arch and Clarke's arch, concluded that there existed a relationship confirmed by high values of correlation between both parameters [19]. The research conducted by Bibrowicz in the group of 6 – 9-year-old children demonstrated that the differences in the height of lower angles of the scapula were observed in a considerable percentage of the children involved in the study irrespective of the size of the spinous process asymmetry. The author pointed out a certain slightly declining trend where the number of children with symmetrical positions of lower scapula angles was increasing as deviation from the line of spinous processes was increasing. The author also observed moderate asymmetries in all children at the level of 32%.

Particular attention was paid to the prevalence of significant asymmetries. The normal spinous process was identified in 17.6%, then this percentage rose to 20% in the group of children with moderate asymmetry and significant asymmetry was recorded in 15% [20]. The study conducted by Micele et al. in the group of pre-school children showed a significant correlation between obesity and overweight and the growing splayfoot with increasing body weight [21]. Villaroya et al., based on the results of measurements among children from Saragossa, observed negative effects of growing body mass on the longitudinal arch of feet and the angle of the location of the great toe [22].

The main objective of the study was to prove environmental dimorphism with regard to the frequency of significant correlations of the selected foot parameters and the features of body trunk in the group of children aged 4-6 years. The analysis of the study results headed in two directions. The first one was to provide an answer to the question: which parameters of feet most frequently revealed a significant correlation with the parameters of body trunk within environmental dimorphism? The second one was to give an answer to the question: which parameters of body trunk most often significantly correlated with the parameters of feet within environmental dimorphism?

2. Material and method

The study conducted with the group of children aged 4 to 6 years enabled to record 2 988 observations including 1 551 in the urban environment (M) and 1 437 in the rural environment (W). Due to the article constraints, the detailed description of the somatic features of the study material and the obtained results are available in the author's monography [23]. 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 comprehensive view of the distribution of the studied features considering age ranges, gender and environment. The correlations and their significance were assessed using p-value and frequency expressed in percentage.

The fundamental assumption of the study was to 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. 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. 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 [23].

Table 1. List of parameters measured for the trunk and foot system,
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 C7 and S1, measured in vertical axis
5	KPT	degree	Angle of extension	Defined as a deviation of the C7-S1 line from vertical position (backwards)
6	KPT -	degree	Angle of body bent	Defined as a deviation of the C7-S1 line from vertical position (forwards)
7	DKP	mm	Thoracic kyphosis length	Distance between LL and C7
8	KKP	degrees	Thoracic kyphosis angle	KKP = 180 – (Beta+Gamma)
9	RKP	mm	Thoracic kyphosis height	Distance between points C7 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 C7-S1 line from the vertical axis to the left
16	KNT	degree		Defined as deviation of the C7-S1 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 Łl 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 S1. 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

Foot parameters

Symbol			Parameters	
No.		Unit	Name	Description
42	DL p	mm	Length of the right foot (p), left foot (l)	Distance between points acropodion and pterion in a plantogram
43	DL l			
44	Sz p		Width of the right foot (p), left foot (l)	Distance between points metatarsal fibular and metatarsal tibial in a plantogram
45	Sz l			
46	Alfa p m	degree	Valgity angle of the hallux of the right foot: Alfa p, of the left foot: Alfa l p. Angle of varus deformity in the right foot: Alfa p m, left foot: Alfa l m.	Angle between the straight line passing through points metatarsal tibial and the most inner one on the medial edge of the heel and the straight line passing through points metatarsal tibial and the most inner one on the medial edge of the great toe
47	Alfa p			
48	Alfa l m			
49	Alfa l p			
50	Beta p m		Angle of varus deformity of the 5th toe of the right foot: Beta p p, of the left foot: Beta l p. Valgity angle of the fifth toe of the right foot: Beta p m, left foot: Beta l m.	Angle between the straight line passing through points metatarsal fibular and the most outer one on the lateral edge of the heel and the straight line passing through points metatarsal fibular and the most outer one on the lateral edge of the fifth toe in a plantogram
51	Beta p p			
52	Beta l m			
53	Beta l p			
54	Gamma P (Gam.P)		Heel angle of right foot (p), of left foot (l)	Angle between the straight line passing through points metatarsal tibial and the most inner one on the medial edge of the heel and the straight line passing through points metatarsal fibular and the most outer one on the lateral edge of the heel in a plantogram
55	Gamma l (Gam.L)			
56	PS p	mm^2	Plantar surface of right foot (p), left foot (l)	Plantar surface of the foot
57	PS 1			
58	DP 1	mm	Length of longitudinal arch 1, 2, 3, 4, and 5 of right foot (P), left	Length of the arch from 1, 2, 3, 4 and 5 metatarsal foot to point pterion
59	DP 2			
60	DP 3			
61	DP 4			

62	DP 5		foot (L)	
63	DL 1			
64	DL 2			
65	DL 3			
66	DL 4			
67	DL 5			
68	WP 1		Height of the arch 1, 2, 3, 4 and 5 of right foot (P), left foot (L)	Distance from the bottom to the highest point of arch 1, 2, 3, 4 and 5.
69	WP 2			
70	WP 3			
71	WP 4			
72	WP 5			
73	WL 1			
74	WL 2			
75	WL 3			
76	WL 4			
77	WL 5			
78	SP 1		Width of the arch 1, 2, 3, 4 and 5 of right foot (P), left foot (L)	Bowstring of the distance of the arch 1, 2, 3, 4 and 5.
79	SP 2			
80	SP 3			
81	SP 4			
82	SP 5			
83	SL 1			
84	SL 2			
85	SL 3			
86	SL 4			
87	SL 5			

Source: author’s own research

3. **Results**

Table 2. Environmental dimorphism of the incidence of significant correlations between the parameters of feet and the parameters of body trunk

(n) M=1551, W=1437 (M = urban, W = rural)

Parameter	Environment		Parameter	Environment	
	M	W		M	W
DLP	9.52		SP5	7.14	
Alfa		4.76	WL1		9.52
BetaP	7.14		WL2		9.52
BetaL	11.9		WL4		9.52
GamP		4.76	WL5		14.28
GamL	7.14	4.76	DL3		4.76
PSL	16.66		DL4		14.28
WP1	4.76	9.52	DL5	4.76	14.28
WP2	4.76		SL4	9.52	
WP3		9.52	SL5	9.52	
DP4	4.76				

Source: author's own research

The analysis of the study results with regard to environmental dimorphism concerning feet parameters most frequently differentiating the significant correlations with the parameters of body trunk revealed the following parameters in the subjects from the urban environment: length of the right foot (DLP), valgity of the fifth toe in both feet (BetaP, BetaL), plantogram of the left foot (PSL), height of the second arch (WP2), length of the fourth arch (DP4) and width of the fifth longitudinal arch in the right foot (SP5), width of the fourth (SL4) and fifth (SL5) longitudinal arch in the left foot. Among the individuals from the rural environment on the other hand, the following parameters can be mentioned: valgity angle of the great toe in the left foot (Alfa), the hill angle of the right foot (GamP), height of the third longitudinal arch in the right foot (WP3) and the first, second, fourth and fifth arch in the left foot (WL1, WL2, WL4, WL5), length of the third and fourth longitudinal arch in the left foot (DL3, DL4), Table 2, Fig. 1.

Table 3. Environmental dimorphism of the body trunk parameters which reveal the most significant correlations with the foot parameters

(n) M=1551 W=1437 (M = urban, W = rural)

Parameter	Environment		Parameter	Environment	
	M	W		M	W
Alfa		10.86	TT-	8.69	10.86
Beta	7.04	10.86	TS	17.39	
Gamma	6.52		LŁW-	15.21	13.04
DKP	6.52	6.52	KLB-	4.34	
RKP	8.69		OL	10.86	
GKP	6.52		UL	10.86	6.52
DLL	4.34	10.03	UK-	4.34	
RLL	4.34		NK-	4.34	
GLL		6.52			

Source: author's own research

The analysis of the study results with regard to environmental dimorphism, concerning trunk parameters most frequently correlating with foot parameters revealed the following parameters among the subjects from the urban environment: inclination angle of the upper thoracic spine (Gamma), height (RKP) and depth (GKP) of thoracic kyphosis, height of lumbar lordosis (RLL), asymmetry of the width of waist triangles with the left triangle being wider (TS), asymmetry angle of the shoulder line with the left shoulder being higher (KLB-), asymmetry of the distance between lower angles and the spinous process with the left angle being more distanced (OL), maximum inclination of the spinous process to the left from the vertical line (UK-) and the horizontal line of this inclination (NK-). Among the individuals from the rural environment, the following parameters are included: the inclination of the lumbosacral spine (Alfa) and depth of lumbar lordosis (GLL), Table 3, Fig. 2.

4. **Conclusions**

1. The number of foot parameters revealing significant correlations with trunk parameters and differentiating both environments is the same. Yet, in the rural

environment the correlation with trunk parameters is slightly higher. The parameters differentiating the rural environment are the features describing the longitudinal arch and the ones relating to the urban environment are describing the morphological characteristics and disorders of the toe position.

2. The number of trunk parameters with which the foot parameters significantly correlate is considerably higher in the individuals from the urban environment and this correlation is more common. The number of sagittal parameters is the biggest, followed by the number of frontal parameters and the smallest number of transverse parameters.

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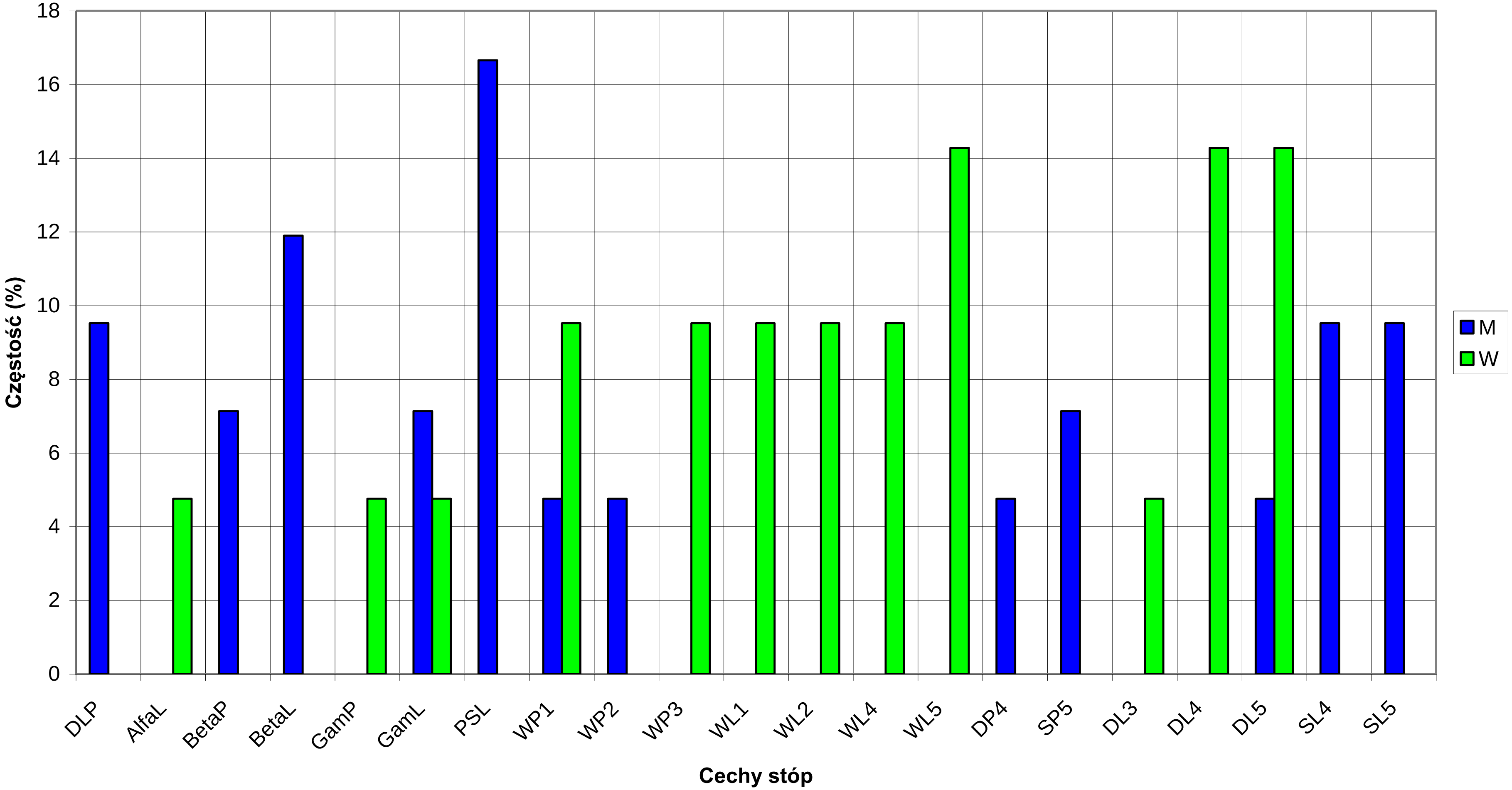
Ryc. 1. Dymorfizm środowiskowy istotnych związków cech stóp z cechami tułowia wśród 4 - 6-letnich dzieci obojga płci (n) M=1551, W=1437



Ryc. 2. Dymorfizm środowiskowy cech tułowia, z którymi cechy stóp wykazują najczęściej istotny związek wśród 4 - 6-letnich dzieci obojga płci (n) M=1551, W=1437