Mrozkowiak Mirosław, Sokołowski Marek, Kaiser Alicja, Posłuszny Mariusz. The incidence of significant relationships between selected parameters of feet and parameters of trunk in children aged 4, 5 and 6 years. Journal of Education, Health and Sport. 2018;8(2):320-333. eISNN 2391-8306. DOI http://dx.doi.org/10.5281/zenodo.1188405
http://ojs.ukw.edu.pl/index.php/johs/article/view/5334
https://pbn.nauka.gov.pl/sedno-webapp/works/858784

The journal has had 7 points in Ministry of Science and Higher Education parametric evaluation. Part b item 1223 (26/01/2017).
1223 Journal of Education, Health and Sport eISSN 2391-8306 7

Received: 05.02.2018. Revised: 10.02.2018. Accepted: 28.02.2018.

The incidence of significant relationships between selected parameters of feet and parameters of trunk in children aged 4, 5 and 6 years

Mrozkowiak Mirosław[1], Sokołowski Marek[2], Kaiser Alicja[3], Posłuszny Mariusz[4]

[1]Kazimierz Wielki University, Bydgoszcz, Poland

[2]University of Physical Education, Poznań, Poland

[3]Department of Didactics of Tourism and Recreation, WSB University in Poznań, Poznań, Poland

[4]Kręg-Clinic, 192 Strzeszyńska Str., Poznań, Poland

Key words: relationship, feet, spine, pelvis

Summary

Introduction. The evolution of information technology has resulted in development of normative ranges with regard to the parameters of human body posture which led to further research of their mutual impact, relationships and concomitance.

Material and method. The study conducted with the group of children aged 4 to 6 years enabled to record 2988 observations with regard to the measurement of the 90 parameters describing trunk and feet. The station for an assessment of body posture and feet using the photogrammetric method consisted of a computer, a card, software, a display monitor, a printer and a projection-reception device with a camera to measure selected parameters.

Findings

1. The values of left foot parameters correlated significantly more with trunk parameters than right foot parameters. Particularly high correlations were observed in the following parameters: length of the fifth arch, surface of plantokonturogram (the plantar side of the feet) and height of the fifth arch, valgity angle of the fifth toe, and heel angle of left foot.
2. Foot parameters revealed the most frequent significant relationship with trunk parameters in the sagittal and frontal planes. Trunk parameters with which foot parameters correlated most often included: asymmetry in the height of both scapulas with the right scapula up, inclination of thoracolumbar region and asymmetry in the height of waist triangles with the right triangle up.

1. Introduction

The evolution of information technology has resulted in development of normative ranges with regard to the parameters of human body posture which led to further research of their mutual impact, relationships and concomitance. This issue has been dealt with by Łubkowska [1] and Mrozkowiak [2]. The study carried out by Plaskiewicz et al. using the mora projection method in the group of forty children aged 9-10 years from rural and urban environments in terms of incidence of foot defects revealed that most children from towns (65%) and villages (75%) had correctly shaped feet. Flat feet were reported to be the most common foot defect among the children involved in the study. No significant statistical differences were observed in the assessment of feet between children from rural and urban settlements [3]. The research conducted by Puzder et al. in the group of 92 children aged 9-10 years from both settlements showed that the living environment did not have significant impact on the incidence of static disorders in lower limbs. However, a decreasing tendency was observed in the frequency of examined defects in lower limbs as the time of physical recreation extended. Additionally, a positive correlation was observed between BMI and the incidence of valgus knees and flat-valgus feet [4]. The study performed by Wojnar et al. in the group of 348 children aged 6-7 years revealed a significant percentage of postural defects. More defected body postures in the sagittal plane were reported in 6-year-old subjects whereas in the frontal plane in children aged 7 years. The shape and size of anteroposterior spinal curves and values of the measured

asymmetry indices did not significantly differentiate boys and girls [5]. The research carried out by Walaszek et al. among 60 children at the age of 5 with regard to the longitudinal arch in feet revealed that girls' right feet had deeper arch than their left feet. Moreover, the authors found out that differences in Clarke's indicator between girls' and boys' left feet were statistically insignificant while girls' right feet statistically varied from right feet of boys [6].

The static and dynamic correlations between the parameters of feet and trunk have been discussed in relatively few publications so far. This problem has been explored by Mięsowicz [7-8], Drzał-Grabiec, Snela [9], Mrozkowiak, Sokołowski, and Jazdończyk [10, 11].

The purpose of the study was to determine the concomitance of significant relationships between selected parameters of feet and trunk in the group of 4, 5, and 6-year-olds of both genders and from rural and urban settlements.

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 significant relationships with the parameters of trunk? The second one was to give an answer to the question: which parameters of trunk most often correlated with the parameters of feet?

2. **Material and method**

The study conducted with the group of children aged 4 to 6 years enabled to record 2,988 observations. The statistical analysis included 90 angular and linear parameters of the spine, pelvis, trunk and feet in the sagittal, frontal and transverse planes, in particular age, gender and environmental ranges, Table 1. The station for an assessment of body posture and feet using the photogrammetric method consisted of a computer, a card, software, a display monitor, a printer and a projection-reception device with a camera to measure elected parameters. Due to the article constraints, the detailed description of the somatic features of the research material and the obtained results are available in the author's monography [2]. 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. Objectified

and comparable test results ensured 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 and the degree of correction achieved by physical exercise. The station for an assessment of selected features body posture and feet using the photogrammetric method consisted of a computer, a card, software, a display monitor, a printer and a projection-reception device with a camera to measure selected parameters of the pelvis – spine complex and feet. 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 back. An uneven distribution of subcutaneous adipose tissue along the back makes it difficult to reliably assess body posture in children, especially those with BMI 25 – 30 and over. It is considerably more difficult to determine selected anthropometric measurements in such subjects.

Table 1. List of parameters measured for trunk and feet.

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	Delta	degree	The sum of angles	Delta = Alfa + Beta + Gamma
5	DCK	mm	Total length of the spine	Distance between C7 and S1, measured in vertical axis
6	KPT	degree	Angle of extension	Defined as a deviation of the C7-S1 line from vertical position (backwards)
7	KPT -	degree	Angle of body bent	Defined as a deviation of the C7-S1 line from vertical position (forwards)

8	DKP	mm	Thoracic kyphosis length	Distance between LL and C_7
9	KKP	degree	Thoracic kyphosis angle	KKP = 180 – (Beta+Gamma)
10	RKP	mm	Thoracic kyphosis height	Distance between points C7 and PL
11	GKP	mm	Thoracic kyphosis depth	Distance measured horizontally between the vertical lines passing through points PL and KP
12	DLL	mm	Lumbar lordosis Length	Distance measured between points S1 and KP
13	KLL	degree	Angle of lumbar lordosis	KLL = 180 – (Alfa + Beta)
14	RLL	mm	Lumbar lordosis height	Distance between points S1 and PL
15	GLL -	mm	Lumbar lordosis depth	Distance measured horizontally between the vertical lines passing through points PL and LL
Frontal plane				
16	KNT -	degree	Angle of body bent to the side	Defined as deviation of the C7-S1 line from the vertical axis to the left
17	KNT	degree		Defined as deviation of the C7-S1 line from the vertical axis to the right
18	LBW -	mm	Right shoulder up	Distance measured vertically between horizontal lines passing through points B2 and B4
19	LBW	mm	Left shoulder higher	
20	KLB	degree	Shoulder line angle, right shoulder up	Angle between the horizontal line and the straight line passing through points B2 and B4
21	KLB –	degrees	Shoulder line angle, left shoulder up	
22	LŁW	mm	Left scapula up	Distance measured vertically between horizontal lines passing through points Ł1 and Łp
23	LŁW-	mm	Right scapula up	
24	UL	degree	Angle of scapula line, right scapula up	Angle between the horizontal line and the straight line passing through points Ł1 and Łp
25	UL -	degree	Angle of scapula line, left scapula up	

26	OL	mm	Lower angle of left scapula more distant	Difference of the distance of lower angles of scapulas from the line of spinous processes measured horizontally along the lines passing through points Ł1 and Łp
27	OL -	mm	Lower angle of right scapula more distant	
28	TT	mm	Left waist triangle up	Difference of the distance measured vertically between points T1 and T2, T3 and T4.
29	TT –	mm	Right waist triangle up	
30	TS	mm	Left waist triangle wider	Difference of the distance measured horizontally between straight lines passing through points T1 and T2, T3 and T4
31	TS -	mm	Right waist triangle wider	
32	KNM	degree	Pelvis tilt, right ilium up	Angle between the horizontal line and the straight line passing through points M1 and Mp
33	KNM -	degree	Pelvis tilt, left ilium up	
34	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.
35	UK -	mm	Maximum inclination of the spinous process to the left.	
36	NK	_	Number of the vertebra maximally distanced to the left (NK-) or to the right (NK)	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 Th5, if from 12.6 to 12.9 it is Th6.
Transverse plane				
37	ŁB -	mm	Lower angle of the right scapula more convex	Difference of the distance of lower scapula angles from the surface of the back
38	ŁB	mm	Lower angle of the scapula more convex	

39	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.
40	UB	degree	Angle of projection line of lower scapula angles, the right one more convex	
41	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
42	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
43	DL p	mm	Length of the right foot (p), left foot (l)	Distance between points acropodion and pterion in a plantogram
44	DL l			
45	Sz p		Width of the right foot (p), left foot (l)	Distance between points metatarsal fibular and metatarsal tibial in a plantogram
46	Sz l			
47	W p		"W" Indicator (Wejsflog indicator) of the right foot (p), of the left foot (l)	The relationship of foot length to its width DL p/Sz p = W p, DL l/Sz l = Wl
48	W 1			
49	Alfa p m	degree	Valgity angle of big toe of the right foot: Alfa p 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
50	Alfa p p			
51	Alfa l m			
52	Alfa l p			
53	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
54	Beta p p			
55	Beta l m			
56	Beta l p			
57	Gamma		Heel angle of right	Angle between the straight line passing

	P (Gam.P)		foot (p), of left foot (l)	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
58	Gamma l (Gam. L)			
59	PS p	mm^2	Plantar surface of right foot (p), left foot (l)	Plantar surface of the foot
60	PS 1			
61	DP 1	mm	Length of longitudinal arch 1, 2, 3, 4, and 5 of right foot (P), left foot (L)	Length of the arch from 1, 2, 3, 4 and 5 metatarsal foot to point pterion
62	DP 2			
63	DP 3			
64	DP 4			
65	DP 5			
66	DL 1			
67	DL 2			
68	DL 3			
69	DL 4			
70	DL 5			
71	WP 1		Height of 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.
72	WP 2			
73	WP 3			
74	WP 4			
75	WP 5			
76	WL 1			
77	WL 2			
78	WL 3			
79	WL 4			
80	WL 5			
81	SP 1		Width of arch 1, 2, 3, 4 and 5 of right foot (P), left foot (L)	Bowstring of the distance of arch 1, 2, 3, 4 and 5.
82	SP 2			
83	SP 3			
84	SP 4			
85	SP 5			
86	SL 1			
87	SL 2			
88	SL 3			
89	SL 4			
90	SL 5			

Source: author's own research

4. **Results**

Table 2. Incidence of significant relationships between the parameters of feet and the parameters of trunk (n) 2,988

Parameters and incidence of significant correlations							
DLP	9.52	PSL	16.66	WL1	9.52	DL5	19.04
AlfaL	4.76	WP1	14.28	WL2	9.52	SL4	9.52
BetaP	7.14	WP2	4.76	WL4	9.52	SL5	9.52
BetaL	11.9	WP3	9.52	WL5	14.28	DL3	4.76
GamP	4.76	DP4	9.52	DL4	9.52		
GamL	11.9	SP5	7.14				

Source: author's own research

The strongest correlations between foot parameters and trunk parameters, that is over 10%, were observed in the following parameters: length of the fifth arch (19.04%), surface of the plantar side of the feet - plantokonturogram (16.66%), height of the fifth arch (14.28%), valgity angle of the fifth toe (11.9%), and heel angle of left foot (11%).

The parameters like height of the first, second, and fourth arch and length of the fourth arch and length of left foot, width of the fourth and fifth arch in the left foot, height of the third arch and length of the fourth arch in right foot revealed a 9.52% relationship. The remaining parameters were below this threshold, Table 2, Fig. 1.

Table 3. Trunk parameters with which feet parameters most significantly correlated (n) 2,988

Parameters of trunk and incidence of significant foot correlations					
Alfa	10.86	DLL	17.39	LŁW-	28.25
Beta	21.72	RLL	4.34	OL	10.86
Gamma	6.52	GLL	6.52	UL	17.39
DKP	13.04	TT-	19.55	UK-	4.34
RKP	8.69	TS	17.39	NK-	4.34
GKP	6.52	KLB-	4.34		

Source: author's own research

Further analysis of the study results showed that parameters of feet most significantly, over 20%, correlated with the angle of body bent to the left in the frontal plane (63.01%) and height of lumbar lordosis (52.15%), inclination of upper thoracic region (41.29%), and length of lumbar lordosis (39.11%). Significant correlations with the height of thoracic kyphosis and asymmetry in the height of scapulas with the right one up achieved the level of 32.59%. Moreover, foot parameters were reported to significantly correlate with length of thoracic kyphosis (13.04%), inclination of lumbosacral region (10.86%) and asymmetry in the distance between lower angles of scapulas from spinous process with the lower left angle of scapula

being more distant. The parameters of feet correlated with the remaining trunk parameters on the level below 10%, Table 3, Fig. 2.

5. **Findings**

1. The values of left foot parameters correlated significantly more with trunk parameters than right foot parameters. Particularly high correlations were observed in the following parameters: length of the fifth arch, surface of plantokonturogram (the plantar side of the feet) and height of the fifth arch, valgity angle of the fifth toe, and heel angle of left foot.
2. Foot parameters revealed the most frequent significant relationship with trunk parameters in the sagittal and frontal planes. Trunk parameters with which foot parameters correlated most often included: asymmetry in the height of both scapulas with the right scapula up, inclination of thoracolumbar region and asymmetry in the height of waist triangles with the right triangle up.

References

1. Łubkowska Wioletta, Normative ranges of physiological spinal curves for children and adolescents in Szczecin, Scientific Journals of Szczecin University, No. 771, Publications of the Institute of Physical Culture, No. 28 2012.
2. Mrozkowiak M., Modulation, impact and relationships of the selected body posture parameters in children and adolescents aged 4 to 18 in the light of mora projection, Publishing House of Kazimierz Wielki University, Bydgoszcz, Volume I, II, 2015 r.
3. Plaskiewicz Anna, Kałużny Krystian, Kochański Bartosz, Wołowiec Łukasz, Hagner Wojciech, Zukow Walery. Assessment of the incidence of feet defects in children aged 9-10 years in the urban and rural environment. Journal of Education, Health and Sport.2015;5(4):325-334.
4. Puzder Anna, Gworys Kamila, Kowalewska Elżbieta, Durka Sylwia, Kunikowska Beata, Kujawa Jolanta, Assessment of the incidence of lower limb statics disorders in children from urban and rural settlements – pilot studies, Kwart. Ortop. 2011, 4, p. 377.
5. Wojna Dorota, Anwajler Joanna, Hawrylak Arleta, Barczyk Katarzyna, Evaluation of body posture in early-school-age children, Physiotherapy 2010, 18, 4, p. 27-39.
6. Walaszek R., Szurmik T., Marszałek A., Walaszek K., Burdacki M., 2014, Assessment of longitudinal arch in feet of 5-year-old girls and boys from rural environments. Zeszyty Zamojskie, Vol. XVI, journal 2, p. 61-71, Zamość, ISSN 1507-9090.

7. Mięsowicz I., 1965, Statodynamic interdependencies within hip region in ontogenetic development. Scientific works and materials IMD, no. 5.
8. Mięsowicz I., 1966, Statodynamic interdependencies within foot region in ontogenetic development. Scientific works and materials IMD, no. 8.
9. Drzał-Grabiec J., Snela S., 2012, Spinal curvatures and foot defects in children: an experimental study, Spine.
10. Mrozkowiak M., Sokołowski M., Kaiser A.: Relationships and influence of pelvis–spine and feet complex features in population of boys and girls aged 14–18 years. Issues of family medicine, September 2012, XIV, No. 3, p. 28-36.
11. Mrozkowiak M., Jazdończyk P., Relationships in the spine-pelvis system and feet in girls and boys aged 4 to 18 years. Journal of Education, Health and Sport. 2015;5(7):226-250.

(Description of the Figures:)

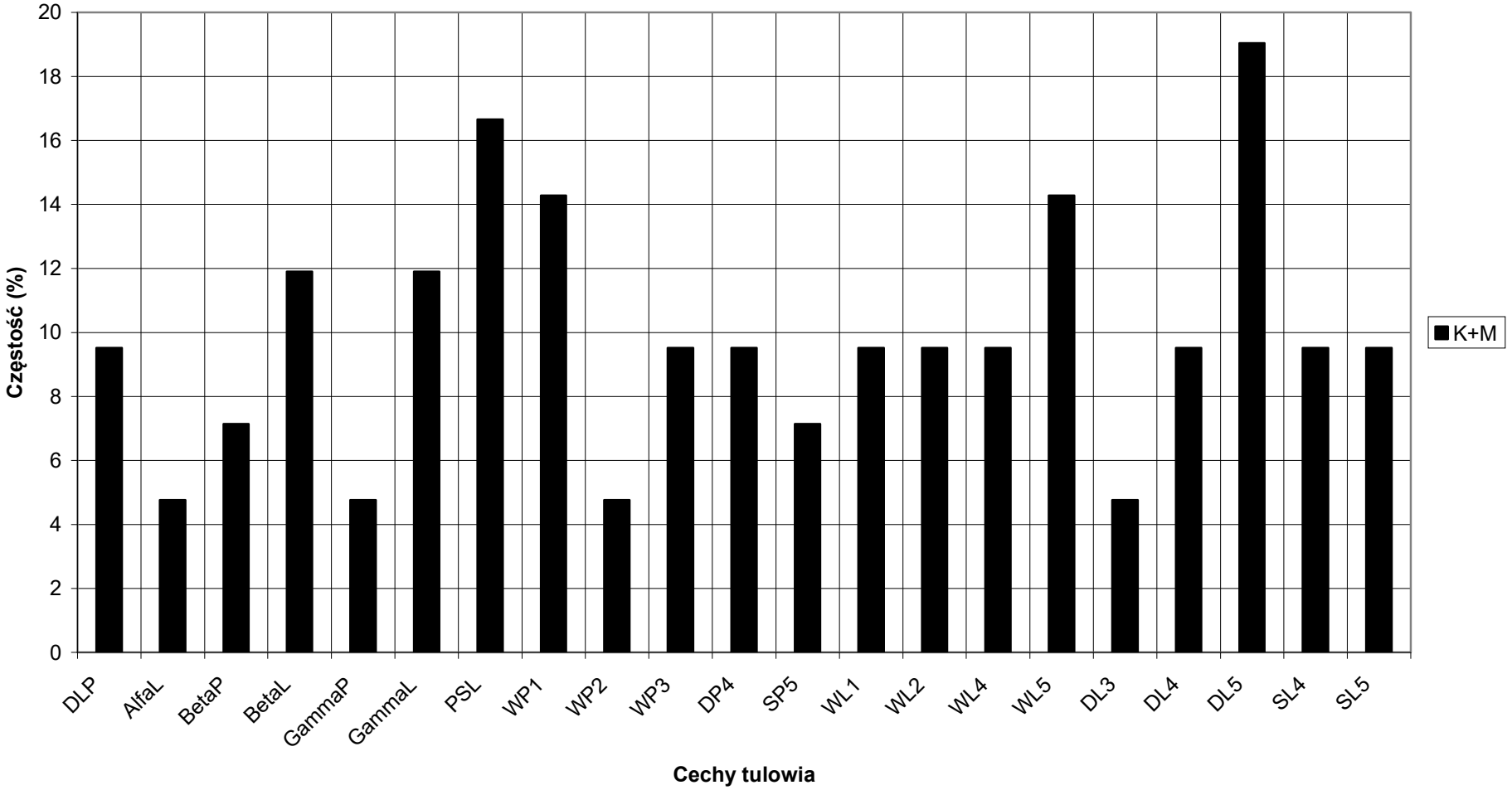
Fig. 1 Sexual dimorphism of the incidence of significant relationships between selected parameters of feet with trunk parameters in children aged 7 – 13 years of both genders and from both environments (n) 2988
Incidence (%)

Parameters of trunk	K (female)	M (male)

Fig. 2 Sexual dimorphism of the incidence of significant relationships between selected parameters of trunk with parameters of feet in children aged 7 – 13 years of both genders and from both environments (n) 2988
Incidence (%)

Parameters of feet	K (female)	M (male)

Ryc. 1. Częstość istotnych związków cech stóp z cechami tułowia wśród 4 - 6-letnich dzieci obojga płci i środowisk (n) 2988



Ryc. 2. Cechy tułowia, z którymi najczęściej istotnie związane są cechy stóp wśród 4 - 6-letnich dzieci obojga płci i środowisk (n) 2899