Mrozkowiak Mirosław, Posłuszny Mariusz, Sokołowski Marek, Kaiser Alicja. The incidence of significant relationships between selected parameters of feet and parameters of trunk in adolescents aged 14-18 years. Journal of Education, Health and Sport. 2018;8(2):305-319. eISNN 2391-8306. DOI http://dx.doi.org/10.5281/zenodo.1188366
http://ojs.ukw.edu.pl/index.php/johs/article/view/5331
https://pbn.nauka.gov.pl/sedno-webapp/works/858745

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
© The Authors 2018;
This article is published with open access at Licensee Open Journal Systems of Kazimierz Wielki University in Bydgoszcz, Poland
Open Access. This article is distributed under the terms of the Creative Commons Attribution Noncommercial License which permits any noncommercial use, distribution, and reproduction in any medium, provided the original author (s) and source are credited. This is an open access article licensed under the terms of the Creative Commons Attribution Non commercial license (Http://creativecommons.org/licenses/by-nc/4.0/) which permits unrestricted, non commercial use, distribution and reproduction in any medium, provided the work is properly cited.
This is an open access article licensed under the terms of the Creative Commons Attribution Non commercial License (http://creativecommons.org/licenses/by-nc/4.0/) which permits unrestricted, non commercial use, distribution and reproduction in any medium, provided the work is properly cited.
The authors declare that there is no conflict of interests regarding the publication of this paper.
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 adolescents aged 14-18 years

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

[1]Kazimierz Wielki University, Bydgoszcz, Poland
[2]Kręg-Clinic, 192 Strzeszyńska Str., Poznań, Poland
[3]University of Physical Education, Poznań, Poland
[4]Department of Didactics of Tourism and Recreation, School of Banking, Poznań, Poland

Key words: relationship, feet, spine, pelvis

Summary

Introduction. The analysis of correlations concerning 2343 observations of more than 150 parameters of body posture revealed that the distribution of significant relationships in each of selected age and gender ranges was incidental and random, therefore it was impossible to prove any regularities or dependencies between the studied parameters.

Material and method. The study conducted with the group of adolescents aged 14 to 18 years enabled to record 2343 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: width and length of right foot and the surface of plantokonturogram (the plantar side of the feet).

2. Foot parameters revealed the most significant relationship with trunk parameters in the sagittal plane, then in the frontal plane to a lesser extent and sporadically in the transverse plane. Trunk parameters with which foot parameters correlated most often included: the angle of body bent to the left side in the frontal plane and height of lumbar lordosis, the inclination of the upper thoracic region, length of lumbar lordosis, height of thoracic kyphosis, asymmetry in height of scapulas with the right scapula up.

1. **Introduction**

Electromyographic studies have revealed that shank muscles and intrinsic muscles of the foot have no impact on the normal static support of the longitudinal arch, yet they have an influence on walking [1, 2, 3]. The intrinsic muscles of the foot are said to function as stabilisers of the talocancaneal joint and the transverse tarsal joint. The significance of the supination positioning of the tarsal in terms of stabilization can be suggested by the fact that adults with flat-valgus feet revealed bioelectric activity of the muscles only after touching the flat-valgus foot to the ground and this activity lasted longer than in normal subjects.

Nevertheless, the muscles were not able to support the longitudinal arch [2, 4]. Rotational movements of the limbs have significant impact on how the longitudinal arch behaves during walking. In the support phase, the shank performs the intrinsic rotation up to ca. 30% of the walking cycle. This movement is accompanied by the force which pronates the tarsal on the coupling basis (analogue of gimbal). This is prevented by a supination tension. Still other studies have shown a pronation of the tarsal in children in the initial phase of support. This is a completely different situation than in adults who tend to have a supination of the tarsal in the phase in which the heel touches the ground. A pronation observed in children in this walking phase results in a certain chain of consequences. The parallel alignment of the axis of the talocancaneal joint and calcaneocuboid joint relaxes the tightness of the transverse tarsal joint and consequently lowers the longitudinal arch. This in turn enables deeper tarsal valgus and so the vicious circle is complete. A diversified image of the tarsal positioning in children during the push-off phase, namely, half of the cases with a supination and another half with a pronation, as opposed to a supination always revealed in adults, suggests a deficiency of the dynamic apparatus of the limb at the moment of the largest burden on the foot in some children. In addition to a deficiency of the capsular-ligamentous apparatus, this is the second pathogenic factor [5].

Own studies and the analysis of correlations concerning 2343 observations revealed that the distribution of significant relationships in each of selected age and gender ranges was incidental and random, therefore, it was impossible to prove any regularities or dependencies between the studied parameters. The concomitance of these parameters can be only determined. Among the parameters describing the pelvis-spine system and most frequently correlating with feet parameters in adolescents aged 14-17 years, it can be observed that the parameters in the frontal and sagittal planes prevail and to a lesser extent in the transverse plane. The investigated age ranges revealed the strongest relationships and concomitance with the parameters of feet in 18-year-old girls and boys aged 15 and 18 years [6].

The purpose of the research was to determine the prevalence of significant correlations between the selected parameters describing feet and trunk parameters in the group adolescents aged 14-18 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 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 methods**

The study conducted with the group of children aged 14 to 18 years enabled to record 2343 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.

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 [7]. 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 [7].

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 Łl 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

Source: author's own research

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 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
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) 2343.

Parameters and incidence of significant correlations							
DLP	21.42	PSP	23.8	SP5	4.76	DL5	16.66
DLL	14.28	PSL	16.66	WL1	11.9	SL1	9.52
SZP	28.56	WP1	9.52	WL2	11.9	SL2	9.52
SZL	9.52	WP2	4.76	WL5	7.14	SL3	16.66
AlfaL	14.28	WP3	9.52	DL1	19.4	DL4	9.52
BetaP	14.28	SP1	7.14	DL2	9.52	SP3	11.9
BetaL	16.66	SP2	11.9	DL3	19.04	GamL	14.28

Source: author's own research

The strongest correlations between foot parameters and trunk parameters, that is over 20%, were observed in the following parameters: width (28.56%) and length of the right foot (21.42%) and the surface of the plantar side of the right foot - plantokonturogram (23.8%). Slightly lower incidence was reported in length of the third arch of the left foot (19.04%). Prevalence of significant correlations on a 16.66% level was shown in such parameters as the surface of plantokonturogram, length of the fifth and width of the third longitudinal arch in

the left foot, and valgity angle of the fifth toe in the right foot. A 14.28% concomitance was observed in the following parameters: valgity angle of the big toe, heel angle, length of the left foot and varus angle of the fifth toe in the right foot. The remaining parameters were below 12%, Table 2, Fig. 1.

Table 3. Trunk parameters with which feet parameters most significantly correlated (n) 2343

Parameters of trunk and incidence of significant foot correlations									
Alfa	4.34	GKP	19.55	KNT-	63.01	UB	15.2	UK-	17,38
Beta	30.41	DLL	39.11	TT-	13.04	UB-	23.9	NK-	6,52
Gamma	41.29	RLL	52.15	TS	15.2	UL	4.34		
DKP	19.56	GLL	23.91	KLB	21.73	LŁW-	32.6		
RKP	32.59	KPT-	6.52	KLB-	26.07	KSM	10.86		

Source: author's own study

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%. A slightly lower incidence on the level of 30.41% was observed in the relationships with the inclination of thoracolumbar region and shoulder line angle with the left shoulder up (26.07%) and the right one achieving 21.73%. A 23.91% concomitance of the correlations was reported in such parameters as depth of lumbar lordosis and projection of lower scapula angles with the lower angle of left scapula was more convex. The parameters of feet correlated with the remaining trunk parameters on the level below 20%, Table 3, Fig. 2.

5. **Findings**

1. The values of left foot parameters correlated significantly more with trunk parameters than right foot parameters. Particularly strong correlations were observed in the following parameters: width and length of the right foot and the surface of this foot's plantokonturogram.

2. Foot parameters revealed the most significant relationship with trunk parameters in the sagittal plane, then in the frontal plane to a lesser extent and sporadically in the transverse plane. Trunk parameters with which foot parameters correlated most often included: the angle

of body bent to the left side in the frontal plane and height of lumbar lordosis, the inclination of the upper thoracic region, length of lumbar lordosis, height of thoracic kyphosis, asymmetry in height of scapulas with the right scapula up.

References

1. Basmajian J. V., Bentzen J., 1954, Surg. Gynec. and Obst., no. 98, p. 662 – 666.
2. Mann R., Inman V. T., 1964, 46A, p. 469 – 481.
3. Sutherland D. H., 1966, Bone Jt. Surg., 48A, p. 66 – 71.
4. Wright D. W., Desai S. M., Henderson W. H., 1964, J. Bone Jt. Surg., 46A, p. 361 – 382.
5. Marciniak W., 1979, Issues of the flat-valgus foot in children. Biomechanical fundamentals of controlling the flat-valgus foot development, Materials from the scientific session in Lublin 4 - 5.12.1979.
6. Mrozkowiak Mirosław, Szurmik Tomasz, Hadlich Roland. Correlations and coexistence of characteristics describing body posture and feet in young people of both sexes aged 14 to 18 years. Journal of Education, Health and Sport. 2017;7(3):630-678.
7. Mrozkowiak M., 2015, 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.

(Description of the Figures:)

Fig. 1 Incidence of significant relationships of the parameters of feet with the parameters of trunk in adolescents aged 14-18 years, of both genders and from both environments (n) = 2343

Incidence (%)

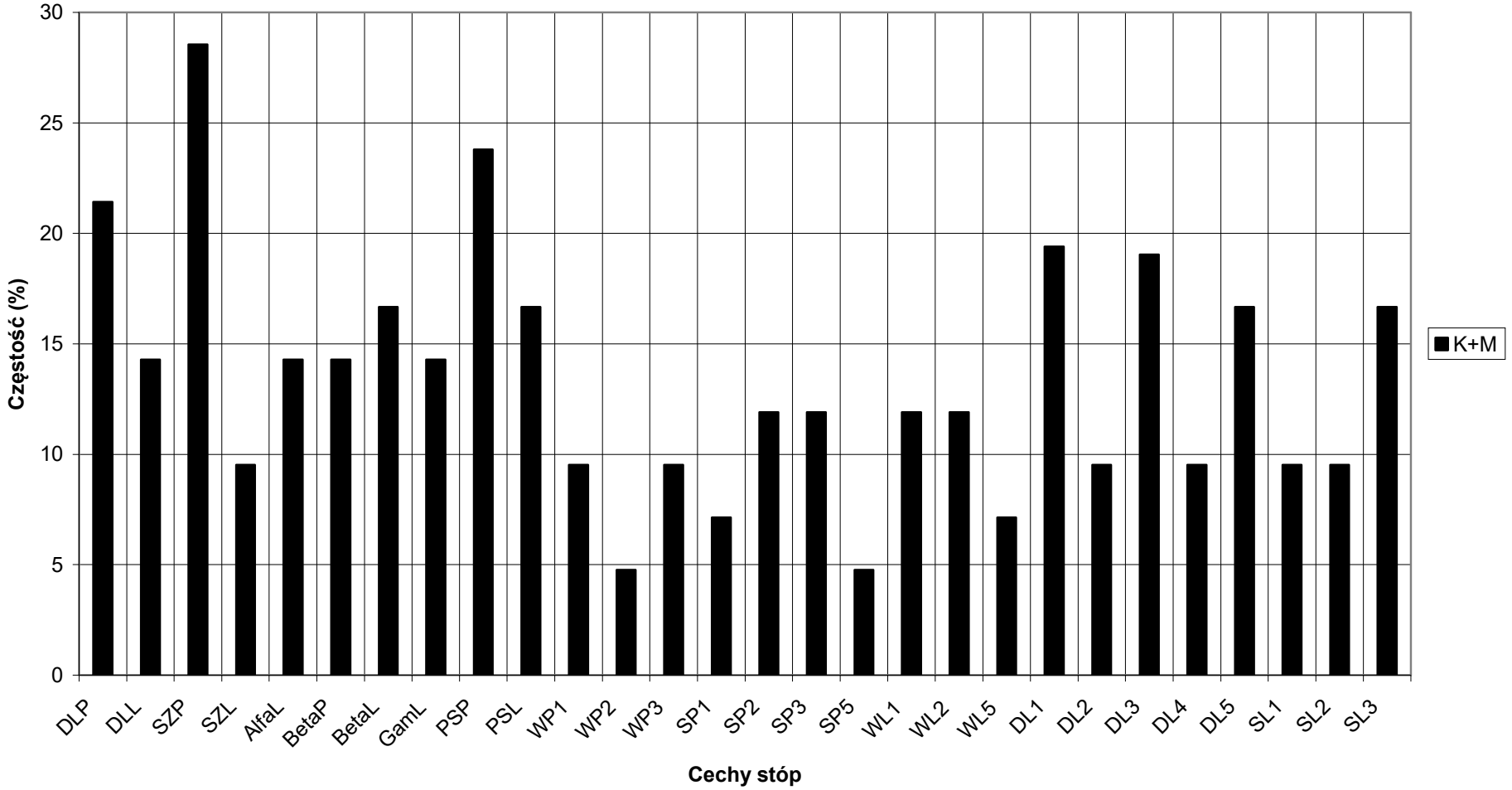
Parameters of feet

Fig. 2 Incidence of significant relationships of the parameters of trunk with the parameters of feet in adolescents aged 14-18 years, of both genders and from both environments (n) = 2343

Incidence (%)

Parameters of trunk

Ryc. 1. Częstość istotnych związków cech stóp z cechami tułowia wśród 14 - 18-letnej młodzieży obojga płci i środowisk (n) 2343



Ryc. 2. Cechy tułowia, z którymi najczęściej istotnie związane sa cechy stóp wśród 14 - 18-letniej młodzieży obojga płci i środowisk (n) 2343