Mrozkowiak Mirosław. Environmental dimorphism of the incidence of significant correlations between feet and body trunk parameters among 14-18-year-old adolescents. Journal of Education, Health and Sport. 2018;8(6):251-264. eISNN 2391-8306. DOI http://dx.doi.org/10.5281/zenodo.1290037
http://ojs.ukw.edu.pl/index.php/johs/article/view/5578

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 declare that there is no conflict of interests regarding the publication of this paper.

Received: 02.05.2018. Revised: 08.05.2018. Accepted: 15.06.2018.

Environmental dimorphism of the incidence of significant correlations between feet and body trunk parameters among 14-18-year-old adolescents

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

Abstract

Introduction. The analysis of correlations between selected parameters of body trunk and feet in 14-18-year-old adolescents revealed their incidental and random character making it impossible to prove any regularities or dependencies between the investigated parameters. Their concomitance can only be determined.

Material and method. The study conducted with the group of adolescents aged 14 to 18 years enabled to record 2 445 observations including 1 167 in the urban environment and 1278 in the rural environment with regard to the measurement of the 87 parameters describing body 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 prevalence of significant correlations between the parameters of body trunk and feet differentiating the urban environment from the rural one is larger. The parameters of the sagittal plane and, to a lesser extent, of the frontal plane, differentiate the urban environment, and only frontal parameters differentiate the rural environment.

2. The prevalence of significant correlations between feet parameters significantly correlating with the parameters of body trunk and differentiating the urban environment from the rural one is bigger. These are morphological features which characterize the longitudinal arch of feet and disorders of the great toe location. The parameters which diversify the rural environment are the features describing the transverse and longitudinal arch.

1. **Introduction**

The analysis of correlations between the selected parameters of body trunk and feet in 14-18-year-old adolescents revealed their incidental and random character making it impossible to prove any regularities or dependencies between the investigated parameters. Their concomitance can only be determined. The parameters of the frontal and sagittal plane, less of the transverse plane, prevailed among the features describing the pelvis-spine complex and most frequently correlating with the parameters of feet in subjects aged 14-17 years. The analysed age ranges revealed the most frequent and strongest correlations and concomitance with the parameters of feet in girls at the age of 18 and boys aged 15 and 18 years [1]. The analysis of the results using p-value test concerning sexual dimorphism in the same group of adolescents proved that the values of trunk parameters in the frontal and sagittal plane significantly correlated with foot parameters and it is worth noting that stronger correlations between the sagittal plane parameters and foot parameters were observed. Interactions between transverse plane parameters are significantly lower. Significant correlations with the parameters of feet are usually observed in the case of angle of body bent in the sagittal plane, height of thoracic kyphosis, angle of the scapular line with the right or left lower angle being more convex, lumbar lordosis length, asymmetry of the height of waist triangles with the right triangle being higher, inclination of the thoracic-lumbar spine, angle of the shoulder line with the left shoulder being higher and the right pelvic tilt in the transverse plane. The foot parameters with which the trunk parameters significantly correlate include: the width of the first longitudinal arch, length of the second longitudinal arch in the right foot, varus angle of the 5^{th} toe and width of the right foot, length of the first arch in the left foot and length of the right and left foot [2]. Own research concerning environmental dimorphism among children at the age of 4-6 years showed that the number of trunk parameters significantly correlating with the foot parameters differentiating the urban environment from the rural one was larger and also the parameters of the urban environment proved to correlate more often with the parameters of feet. The number of foot parameters with which trunk parameters had significant correlations and differentiating the urban environment from the rural one was bigger. Additionally, these parameters revealed more frequent interactions with the foot parameters than in the rural environment. The same analysis of research results among adolescents aged 14-18 years showed that the number of trunk parameters significantly correlating with the foot parameters differentiating the rural environment from the urban one was bigger and the parameters of the urban environment revealed more frequent correlation with the parameters of feet. Apart from that, the number of foot parameters with which the trunk parameters significantly correlated and differentiating the rural environment from the urban one was larger, whereas the parameters of the urban environment revealed more frequent relationships with foot parameters than in the rural environment.

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 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 body trunk most frequently revealed a significant correlation with the parameters of feet 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 and adolescents aged 14 to 18 years enabled to record 2 445 observations including 1 167 in the urban environment (M) and 1 278 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 [3]. 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 was 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 determined 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 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 categories and environment, Table 1. Obtaining the spatial picture was possible thanks to displaying the line of strictly defined parameters on a subject's back and feet. The lines falling on the skin of a person 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 photo recorded an image of the silhouette displayed on an individual's skin [3].

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	c 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 T_1 and T_2, T_3 and T_4.
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 T_1 and T_2, T_3 and T_4
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 tri	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 UB_1 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 foot (L)	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			
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=1167, W=1278 (M = urban, W = rural)

Parameter	Environment		Parameter	Environment	
	M	W		M	W
DCK	13.71		ŁB	3.92	7.84
Alfa	13.72		OL		3.92
Beta	21.56	5.88	UL	5.88	
Gamma	5.88	13.72	KLB		9.8
KKP	11.76	5.88	KLB-	5.88	17.64
RKP	17.64	21.56	UB	27.45	13.72
DKP	11.76		UB-	33.33	23.52
GKP	7.84	5.88	LŁW-		11.76
KLL	17.64		TS		11.76
DLL	25.49	5.88	TT-	11.76	
RLL	15.68	9.8	KNM	3.92	3.92
GLL	13.72	7.84	KSM	9.8	7.84
KNT		13.72	UK-	7.84	9.8
KNT-	7.84	5.88	NK-	7.84	5.88
KPT-	11.76				

Source: author's own research

The analysis of test results regarding environmental dimorphism of the trunk parameters most often differentiating the correlations with the foot parameters showed that these were the values of the following parameters among the probands from the urban environment: the total length of spine (DCK), inclination of the lumbosacral spine (Alf), thoracic kyphosis length (DKP), angle of lumbar lordosis (KLL), asymmetry of the height of waist triangles with the right triangle being higher (TT-), asymmetry of the scapular line angle with the right scapula up (UL). The analysis of test results obtained from probands from the rural environment proved that the differentiating parameters included: angle of body bent to the right in the frontal plane (KNT), asymmetry of the width of waist triangles with the left one being wider (TS), angle of the shoulder line with the right shoulder up (KLB), asymmetry of scapular height with the right scapula up (LŁW-), asymmetry of distance between lower angles from the line of the spinous process with the angle of the left scapula being more distant (OL), Table 2, Fig. 1.

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

(n) M=1167, W=1278 (M = urban, W = rural)

Parameter	Environment		Parameter	Environment	
	M	W		M	W
SZP	10.8	15.1	DP1	15.2	8.6
SZL	13.0	6.5	DP2	25.9	10.8
DLP	8.6	15.1	DP3		6.5
DLL	21.7		SP1	19.9	
AlfaL	6.5		SP3	13.0	
BetaP	21.7	8.6	SP5	8.6	
GamP	6.5	8.6	WL1	8.6	10.8
GamL		8.6	WL2		8.6
PSP	13.4	13.0	WL4		8.6
PSL	8.6		DL1	10.8	13.4
WP1	8.6		DL4	6.5	6.5
WP2	8.6	6.5	SL1	6.5	6.5
WP4		6.5	SL3	8.6	8.6
WP5	13.4		SL5	6.5	

Source: author's own research

The analysis of the study results with regard to environmental dimorphism, concerning foot parameters most frequently correlating with body trunk parameters revealed the following parameters among the subjects from the urban environment: the length of the left foot (DLL), valgus angle of the great toe (Alfa) and plantar surface (PSL) of the left foot, height of the first and fifth longitudinal arch of the right foot (WP1, WP5), width of the first, third and fifth arch of the right foot (SP1, SP3, SP5) and width of the fifth arch (SL5) of the left foot. As for the results obtained from the probands from the rural environment, the parameters included: the heel angle (GamL) of the left foot, height of the fourth longitudinal arch and length of the third arch of the right foot (WP4, DP3), height of the second and fourth arch of the left foot (WL2, WL4), Table 3, Figure 2.

4. Results

1. The prevalence of significant correlations between the parameters of body trunk and feet differentiating the urban environment from the rural one is larger. The parameters of the sagittal plane and, to a lesser extent, of the frontal plane, differentiate the urban environment, and only frontal parameters differentiate the rural environment.

2. The prevalence of significant correlations between feet parameters significantly correlating with the parameters of body trunk and differentiating the urban environment from the rural one is bigger. These are morphological features which characterize the longitudinal arch of feet and disorders of the great toe location. The parameters which diversify the rural environment are the features describing the transverse and longitudinal arch.

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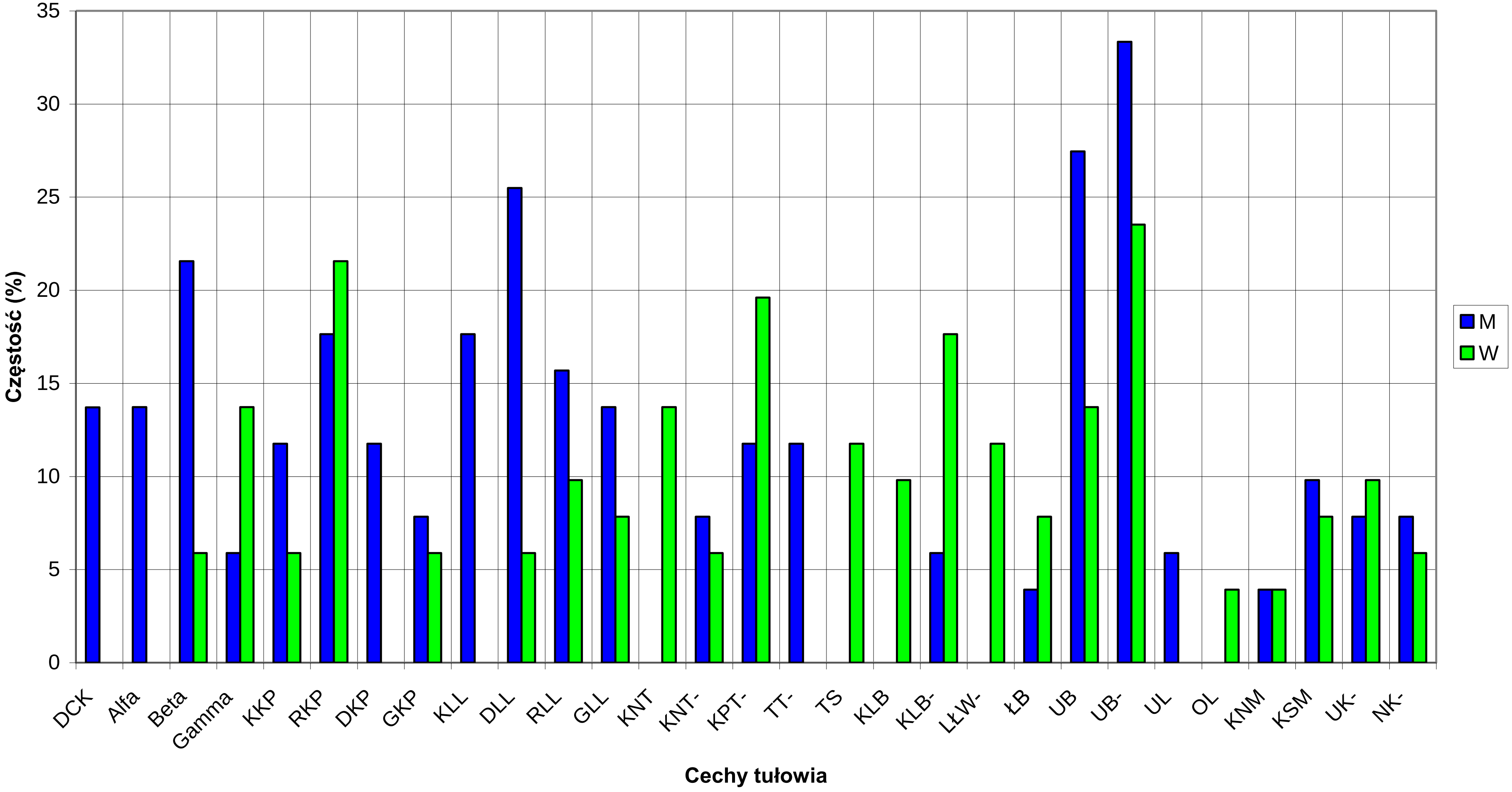
Ryc. 1. Dymorfizm środowiskowy istotnych związków cech tułowia z cechami stóp wśród 14 - 18-letniej młodzieży (n) M=1167, W=1278



Ryc. 2. Dymorfizm środowiskowy cech stóp o najczęstszych związkach z cechami tułowia wśród 14 - 18-letniej młodzieży (n) M=1167, W=1278