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Sexual and environmental dimorphism of the incidence of significant correlations between body weight and height and foot parameters among 14-18-year-old adolescents

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Abstract

Introduction: The objective of this study was to show the frequency of significant correlations between body weight and height and the selected parameters of body posture within trunk in 14-18-year-old adolescents.

Material and methods. The study which was conducted among randomly selected teenagers aged 14-18 years during the period of 3 years, in 6 half-year editions, enabled the author to record 2445 observations with regard to the measurement of 48 parameters describing trunk, body weight and height. The subjects involved in the study were enrolled from the Warminsko-Mazurskie region. The photogrammetric method with the phenomenon of mora projection was used to measure the selected parameters.

Findings. The frequency of significant correlations between body height and the features of body posture was 21.42% and with regard to body weight it was 14.28%. The frequency of significant correlations between body height within sex was 14.28%, and concerning body weight it was 4.76%, whereas among girls the figures were 7.14% and 9.52% respectively.

Conclusions

1. Among adolescents aged 14-18 years, body height revealed significantly more frequent correlations with the parameters of feet than body weight.
2. Body height was reported to reveal more frequent significant correlations with the parameters of feet than body weight among boys. As regards girls involved in the study, the frequency of these significant relationships was similar and revealed lower values. Body weight and height showed more frequent correlations with the parameters of feet in children living in towns and cities than in their counterparts from the rural environment.
3. Among boys, more frequent significant correlations between body height and the parameters of feet were observed in subjects living in the urban environment, and the correlations concerning body weight significantly differed from the percentage of the relationships regarding body height. Among girls living in the rural environment, the correlations between body height and the parameters of feet were more frequent than in the subjects living in towns, and regarding weight, these correlations were reported to be bigger in towns than in villages. The percentage of significant relationships was very low in the rural environment.

Key words: somatic characteristics, parameters of body posture

Dymorfizm płciowy i środowiskowy częstości istotnych związków masy i wysokości ciała z cechami stóp wśród 14-18 – letniej młodzieży

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1. Introduction

Postural defects are a recurring problem discussed in numerous magazines and journals. Leading a lifestyle which is incompatible with the Decalogue of a Healthy Lifestyle understood here as a set of 10 rules by Cendrowski, is conducive to disorders related to posturogenesis development. Reducing the percentage of posture mistakes represents a considerable challenge especially among 6-12-year-old children.[1-6] The development of information technology has enabled a comprehensive approach to the assessment of body posture, the positioning of particular components in time and space and capturing the spatial counterbalance of vertical body posture. The choice of the assessment method with regard to body posture should arise from the objective of the study and the use of measurement results obtained. One of methods necessary to identify the parameters of body posture in a very sophisticated way is photogrammetry based on the phenomenon of mora projection.[7-11]

According to a systematic literature review of the issue mentioned herein, it is clear that authors often focus on correlations between body weight and feet architecture in various aspects.[12-14] Feet are a significant static and dynamic link in the musculoskeletal system as they keep body mass within the real limits of balance thus providing this mass with a drive at the same time.[15] The issue of interdependence between somatic characteristics and parameters of feet usually relates to correlations concerning the longitudinal foot arch.[16,17] A large percentage of disorders connected with body posture statics is often associated with a sedentary lifestyle as well as with body weight and height. The environment of a student considerably affects the type and magnitude of mistakes, particularly during the period of school shock.[18,19] The study conducted by Puszczałowska-Lizis in the group of 280 students aged 20-28 years revealed correlations between the transverse foot arch and thigh circumference. In addition, it was reported that the Wejsflog index of the left foot correlated with body height, relative length of lower limbs and length of the right and left foot. The transverse foot arch, in turn, correlated with body height, length of lower limbs and length of feet in men involved in the study, whereas in women the transverse foot arch also interacted with thigh circumference.[20] The study carried out by Jankowicz-Szymańska et al. among the group of 90 students displayed gender-based differences regarding all examined somatic characteristics except for the thickness of the subscapularis. An overall assessment of the

formation of feet was reported to be similar in women and men. The subjects revealed significant differences in terms of the position of the head of the talus bone and the height of the longitudinal medial arch. The position of the head of the talus bone correlated with body weight and waist circumference as well as BMI and WHR values, whereas the height of the longitudinal medial arch with BMI.[21] The study performed by Walaszek et al. on somatic characteristics and parameters of body posture in the group of 21 girls revealed that body height statistically significantly correlated 4 times with posture parameters.[22] Other studies conducted by this author in a group of 140 student girls from the first class of junior secondary school showed that body weight significantly positively correlated with negative trunk inclination, but negatively with positive lumbar lordosis inclination and with negative difference of the distance of scapula inferior angles. Furthermore, it was demonstrated that body height positively correlated with an increase in the left inferior angle of the scapula, increased left waist triangle, the difference between the height of posterior superior iliac spines and negative maximal deviation of the spinous process from the straight line C_7-S_1.[23]

The objective of this study was to show the frequency of significant correlations between body weight and height and the selected parameters of body posture within trunk in 14-18-year-old adolescents. The analysis of the research findings headed in four directions. The first one was to provide an answer to the question: which parameters of the trunk, pelvis and spine most frequently revealed a significant relationship with body weight and height at the age of 14-18 years? The second and third directions were to give an answer to the question: with which parameters was a significant correlation revealed within sexual and environmental dimorphism? Finally, the fourth one was an answer to the question: what was the frequency of significant correlations of body weight and height in boys and girls within each environment?

2. Material and method

The studies conducted on 14-18-year-old adolescents during 3 years in 6 half-year editions allowed the author to record 2445 observations including 1248 girls and 1197 boys. The statistical analysis covered body weight and height and 48 angular and linear parameters of feet in particular age, sex and environmental categories, see Table 1. Due to the article constraints, the detailed description of the somatic features of the study material and the results obtained are available in the author's monography.[9]

The key assumption of the study was to always assess the habitual posture as a relatively constant individual characteristic of a human being. This posture reflects an individual

emotional, psychical and social condition of the subject. Moreover, this posture provides the most reliable description of the subject's silhouette at a given time and in a place.

The conducted diagnostics does not determine whether an individual's posture is correct or not, it only identifies the condition of its ontogenetic development. 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. The measuring instrument used in the study determined several tens of parameters describing the feet. Obtaining the spatial picture was possible thanks to displaying the line of strictly defined parameters on a subject's feet. 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 an individual's skin[9].

The empirical data was 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 relationships and their significance were assessed using p-value and frequency expressed in percentage.

Table 1. The List of recorded parameters of feet, body weight and height

Symbol			Parameters	
No.		Unit	Name	Description
1	DL p	mm	Length of the right foot (p), left foot (l)	Distance between points acropodion and pterion in a plantogram
2	DL l			
3	Sz p		Width of the right foot (p), left foot (l)	Distance between points metatarsal fibular and metatarsal tibial in a plantogram
4	Sz l			
5	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
6	W 1			
7	Alfa p m	degree	Valgity angle of big toe of the right	Angle between the straight line passing through points metatarsal tibial and the
8	Alfa p p			

9	Alfa l m		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.	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
10	Alfa l p			
11	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
12	Beta p p			
13	Beta l m			
14	Beta l p			
15	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
16	Gamma l (Gam. L)			
17	PS p	mm^2	Plantar surface of right foot (p), left foot (l)	Plantar surface of the foot
18	PS 1			
19	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
20	DP 2			
21	DP 3			
22	DP 4			
23	DP 5			
24	DL 1			
25	DL 2			
26	DL 3			
27	DL 4			
28	DL 5			
29	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.
30	WP 2			
31	WP 3			
32	WP 4			
33	WP 5			
34	WL 1			
35	WL 2			
36	WL 3			
37	WL 4			
38	WL 5			

39	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.
40	SP 2			
41	SP 3			
42	SP 4			
43	SP 5			
44	SL 1			
45	SL 2			
46	SL 3			
47	SL 4			
48	SL 5			

49	Mc	kg	Body mass	Measurements were conducted on the medical scales with accuracy to 0.5 cm and 100g.
50	Wc	cm	Body height	

Source: author's own research

3. Findings

An average height of boys involved in the study was higher than the height of girls examined. Statistically significant differences were observed in an age range of 13-18 years. An average body weight of subjects revealed statistically insignificant differences between sexes except for the age of 15, 16 and 17 years. Dynamics of weight and height increase in both sexes partially overlapped. The differences in the occurrence of build types in individuals of both sexes from urban and rural areas became blurred. In the female population, the distinctions were statistically insignificant, whereas in the male one some differences were reported in the slender build type the prevalence of which was higher in villages and in medium build more common in towns and cities. The difference between the occurrence of fat deposition patterns in both sexes in rural and urban areas also became blurred. With regard to female population, statistically significant dissimilarities were only observed in overweight individuals living in the urban environment. Male population, in turn, revealed significant differences in urban areas, where the number of overweight and underweight individuals was higher. It can be stated with a careful approach that the differences noted between somatic parameters of adolescents may be connected with clearer pubertal development occurring in the subjects representing the regions of the country being compared. This process may prove a considerable diversification of puberty within the groups compared. This strongly suggests that the same age group is represented by subjects who undergo early, average and late advancement of puberty. Differences in average body weight, height, build types and fat deposition patterns may result from the increasing leptosomisation of the survey group.

Body weight revealed a significant correlation with the following parameters: length, width and varus inclination of the fifth toe, length of the first, second and third longitudinal arch, and plantoconturogram and valgus inclination of the right great toe, length of the fourth longitudinal arch of the left foot, width of the first, second and third longitudinal arch of the right foot and the second longitudinal arch of the left foot, height of the second, third and fourth longitudinal arch of the right foot and the first, second, third and fourth longitudinal arch of the left foot. Body height significantly correlated with: length and width of feet, sole surface and valgus inclination of the great toe in both feet, valgus of the fifth toe in the right foot, length of the first, second and third longitudinal arch of the right foot and the first, second, third and fourth longitudinal arch of the left foot, width of the third longitudinal arch of the right foot, the first, second, third and fourth longitudinal arch of the left foot, height of first, second, third and fourth longitudinal arch of the right foot and five longitudinal arches of the left foot.

The statistical analysis suggested that the frequency of significant correlations between body height and foot parameters in 14-18-year-old adolescents was 68.75% and in case of body weight it was 50.0%. Interference concerning the frequency of significant correlations only within gender showed that among boys the frequency regarding body height correlations was 64.58% and with body weight it was 33.33%. As far as girls were concerned, the figures were respectively 50.0% and 27.08%. The profile of the environmental analysis revealed that the frequency of significant correlations between body height and foot parameters was 60.5% and body weight 36.58% in individuals living in urban areas. As for subjects from rural areas, the numbers were respectively: 50.0% and 20.83%, Tab. 2, Fig. 1.

More detailed defining of the percentage of significant environmental correlations suggested that among boys from towns and cities, body height correlated with foot parameters at the level of 52.08%, and body weight at 18.75%, whereas among male subjects from villages the numbers were respectively: 39.58% and 14.58%. The frequency of significant correlations concerning body height among girls from urban areas was 31.25%, body weight 22.91%, and among girls from rural areas 37.5% and 4.16%, Table 3, Fig. 2.

Table 2.The percentage of significant correlations between body weight and height and the parameters of feet with regard to gender and environment (n) K=1248; M=1197 (K=female; M=male)

Profile of the analysis	Body height and weight	Correlation percentage
Age from 14	Wc	68.75

to 18 years	Mc	50.0
Sex	M Wc	64.58
	M Mc	33.33
	K Wc	50.0
	K Mc	27.08
Environment	M Wc	60.5
	M Mc	39.58
	W Wc	50.0
	W Mc	20.83

Source: author's own study

Legend: Wc – body height, Mc – body weight, line "Sex": M – male sex, K – female sex, line "Environment": M – urban, W – rural.

Table 3. The percentage of significant correlations between body weight and height and the parameters of feet in female and male subjects from both environments (n) K=1248; M=1197 (K=female; M=male)

Profile of the analysis	Body height and weight	Correlation percentage
M M	Wc	52.08
	Mc	18.75
M W	Wc	39.58
	Mc	14.58
K M	Wc	31.25
	Mc	22.91
K W	Wc	37.5
	Mc	4.16

Source: author's own study

Legend: MM – male sex, urban, MW – male sex, rural, KM – female sex, urban, KW – female sex, rural.

Discourse

As yet, the literature of the subject has not mentioned any research results determining the frequency of significant correlations of somatic features with selected parameters of trunk. Authors have rather focused on identifying some correlations or on the coexistence of body height and weight with foot parameters, less often with trunk parameters. A pilot study, conducted by Drzał-Grabiec and Snela on the population of 563 girls and boys at the age from 7 to 9 years, allowed the researchers to determine relationships between longitudinal arch of the right and left feet calculated using Clarke's angle and length parameters describing body posture. According to studies performed, there is a statistically significant correlation between longitudinal arch of both feet calculated using Clarke's angle and spine height calculated between points C_7 and S_1. This correlation is confirmed when taking the subgroups of boys

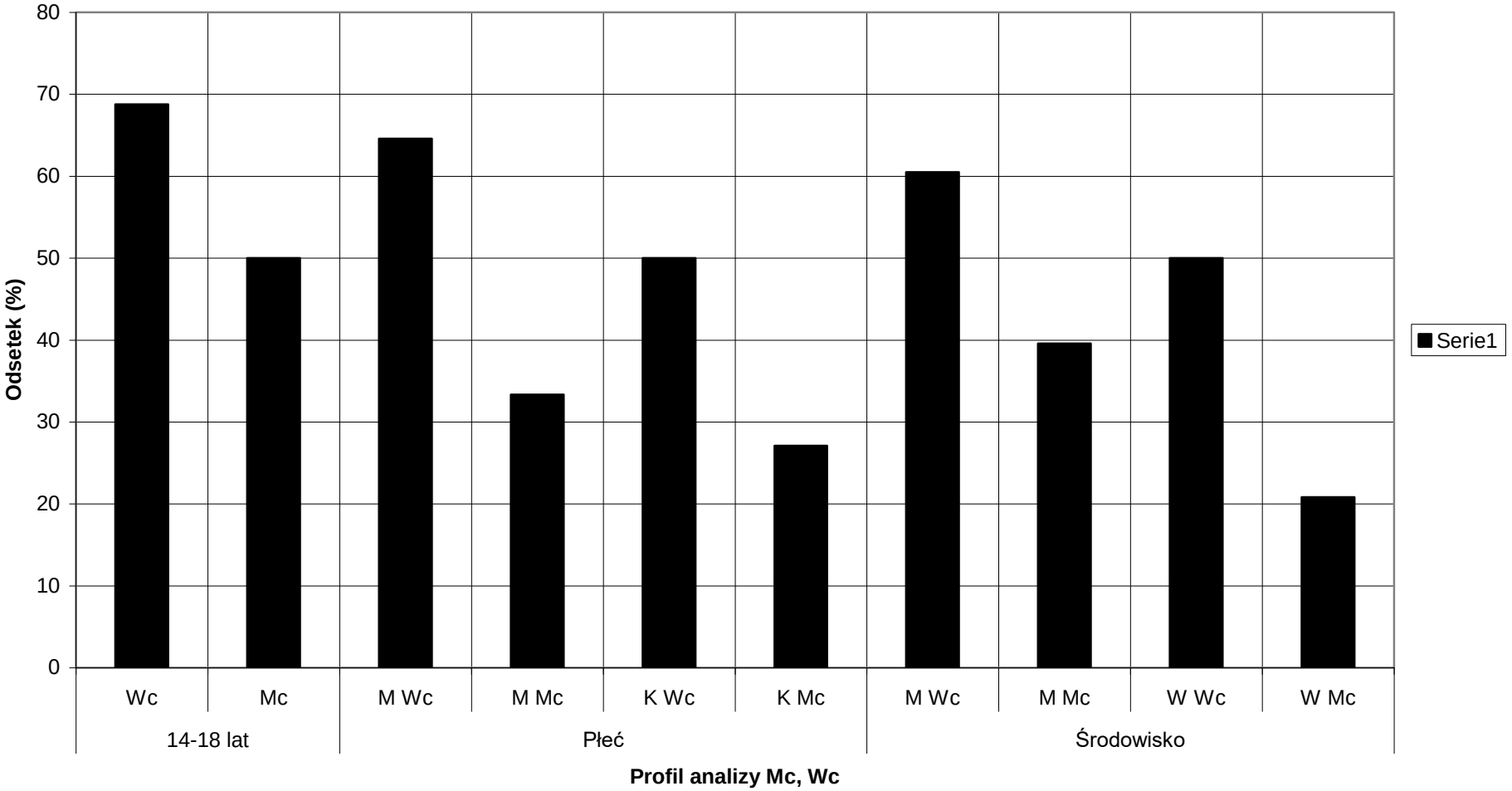
and girls and age subgroups into consideration. Age ranges showed only a statistically significant correlation in the group of 9-year-olds.[24] The studies carried out by Barszczyk et al. revealed that both body mass deficiency and overweight provided conducive biomechanical conditions for disorders in the statics of the musculoskeletal system, the positioning of lower extremities and foot arches. [25] Similar conclusions were drawn by other authors as well. [26,27] Górniak et al. came to a conclusion that sagittal curvatures of incorrect angular and linear parameters occurred regardless of fat deposition in 50% of diagnosed children. Incorrect body postures were observed most often in subjects with excessive fat deposition.[28]

The research concerning body posture and mass conducted by Ostrowska et al. in a group of 70 children suggested that excessive body weight and fat deposition increase led to gradual flattening of thoracic kyphosis or even to linear dependence in case of lumbar lordosis. [29] Similar conclusions were drawn by Grabara et al. and Bogucka and Głębocka.[25] The studies performed by Maciałczyk-Paprocka et al. in a group of 1,176 pupils aged 7-12 years demonstrated that overweight and obesity predisposed to the occurrence of postural defects, especially among girls. [31] Wilczyński came to a conclusion based on the results of measurement conducted on the population of 503 children at the age of 12-15 years that individuals with sagittal plane posture defects were shorter, lighter and with lower BMI, and the highest rate of sagittal plane posture defects was observed in a group with height, weight and BMI below the 25th quartile. The author also proved that sagittal plane posture defects most often appeared among children with fragile body build. He did not observe any correlations between incidence of sagittal plane posture defects and height, weight and BMI expressed in quartiles.[32]

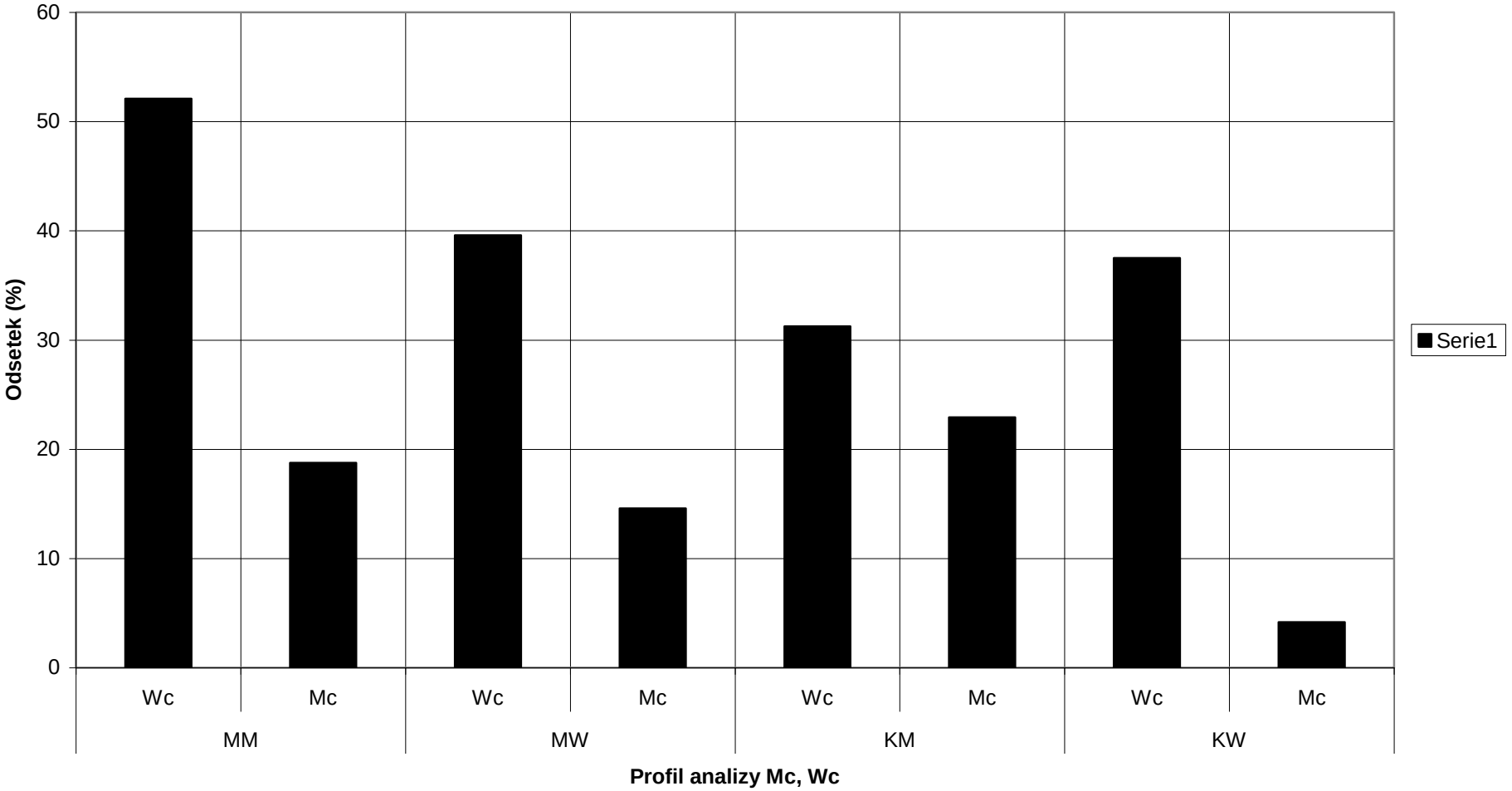
Fig. 1. The percentage of significant correlations between body weight and height and the parameters of feet with regard to age, gender and environment range (n) K=1248; M=1197 (K=female; M=male)

Fig. 2. The percentage of significant correlations between body weight and height and the parameters of feet in female and male subjects with regard to environment K=1248, M=1197 (K=female; M=male)

Ryc. 1. Odsetek istotnych zwiazków masy i wysokości ciała z cechami stóp w zależności od przedziału wieku, płci i środowiska (n) K=1248, M=1197



Ryc. 2. Odsetek istotnych związków masy i wysokości ciała z cechami stóp osobników płci żeńskiej i męskiej w zależności od środowiska K=1248, M=1197



Conclusions

1. Body height correlated significantly more frequently with foot parameters than body weight in 14-18-year old adolescents.

2. Among the boys involved in the study, body height showed a more frequent significant

correlation with foot parameters than body weight. As regards girls, the frequency of these significant relationships was similar and lower. Among individuals from urban areas, body weight and height revealed more frequent correlations with foot parameters than among their counterparts living in rural areas.

3. Boys from urban areas were reported to have more frequent significant correlations between body height and foot parameters, and body weight correlations significantly differed from the percentage of body height correlations. With regard to girls living in rural environment, correlations between body height and foot parameters were more frequent than in towns and cities, and in case of body weight they were more frequent in towns than in villages. Yet, the percentage of significant correlations in rural areas was very low.

4. The correlations presented herein are important from the viewpoint of posturogenesis development in the selected age range. They should highlight an undeniably large impact of body height and weight on posture features within trunk and not only in knee joints and feet.

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