BODY BUILD TYPES VS ARCHES OF THE FEET IN STATIC WEIGHT BEARING CONDITIONS

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Abstract:
Introduction: The body build and its assessment allows us to determine the degree of physical development of a child. Lack of normal physical development increases the risk of occurrence of somatic disorders and disorders within the musculoskeletal system. The topic of the research undertaken was the assessment of types of body build as well as of the longitudinal and transversal arch of the feet. An attempt was made to find a correlation between the parameters being tested. **Material and methods**: The research covered in total 181 pupils from a primary school in Zarzecze, in the Przeworsk poviat (Podkarpackie voivodship). The people tested were divided into two groups: one of 10-11 year olds and the other of 12-16 year olds, with consideration to the gender. The measurements of selected somatic features: height, body mass, skinfold and girths were performed. The results of the measurements allowed for the determination of body build types. The measurements of the linear indices and the arch of the feet were performed by means of the 2 D Foot Cad podoscan. The results were analysed, considering the basic measures of descriptive statistics as well as Spearman's rank correlation coefficient, with the difference significance $\alpha = 0.05$. **Results**: The results of the research showed lack of essential differences in the foot build in the younger age group as well as significant correlations between the type of body build and the Wejsflog index, with insignificant correlations between the body build and the longitudinal arch of the foot, regardless of the age and the gender. **Conclusions**: At the age of 10-11, linear measurements of the feet are similar, regardless of the gender and the age, which do not differentiate transversal arches of the foot, with a small differentiation of the longitudinal arches in the case of older boys. At the time of puberty, differentiation of the length and width of feet occurs, with respect to the gender of the tested people. The type of body build affects the transversal arches of the feet in both girls and boys, assuming a varied direction of relationship.

INTRODUCTION

The body build and its assessment allows us to determine the degree of physical development of a child, which indicates regularities or abnormalities in the process of continuous biological progress. The needs of the children, especially of school age, are associated with spontaneous motor activity, which should be consciously chosen, depending on the age, gender and the interests of the children. Often, these natural needs are limited by the adults who do not understand the regularities of the biological development of a young organism [Charzewska J, 2011]. Lack of normal physical development and motor activity

increases the risk of occurrence of obesity and overweight, which may result in developmental diseases as well as in bad posture. The research covering children from Poznań revealed a correlation between the occurrence of bad posture and overweight and obesity [Maciałczyk – Paprocka K. 2013].

In Poland, approximately every seventh child of school age has too big a mass compared to his or her height [Małecka - Tendera E., Klimek K., Matusik P., Olszanecka-Glinianowicz M., Lehingue Y. 2005]. However, the occurrence range of the phenomenon of bad posture at school age varies in the results of research, most probably, due to the application of different definitions and methods of diagnosing bad posture.

The field of bad posture, covering the issues of functional changes within lower limbs, including feet, constitutes the topic of numerous publications [Demczuk – Włodarczyk E. (2003); Górniak K. Lichota M., Popławska H., Dmitruk A. (2014); Łuba R., Olejniczak Z., Woźniak B. (2014); Mucha D., Knapik H., Mucha T., Niewiadomska – Matuła A. (2005); Rykała J., Snela S., Drzał – Grabiec J., Podgórska J. et al. (2013); Janiszewska R., Tuzinek S., Nowak S., Ratyńska A., et al. (2009)].

The foot, besides its static-dynamic function, thanks to the system of longitudinal and transversal arches, plays an essential role in the mechanics of walking and shock absorption for the spine. Shaping of arches of the feet at various phases of a child's ontogenesis varies slightly. The knowledge of that topic constitutes an essential scientific and cognitive message, which became the basis for this research.

AIM OF THE WORK

The aim of the research undertaken was to assess the types of body build of children from one of the primary schools from the Podkarpackie voivodship, based on the results of the measurements of certain body components, indicating the build type, and to obtain measurements of feet describing their arching. An attempt was also made to search for a correlation between selected morphological features and the degree of longitudinal and transversal arching of the feet of the girls and boys being tested.

RESEARCH QUESTIONS:

1. Do differences in the linear measurements of feet in the developmental, prepubertal phase of children occur depending on gender?
2. Is the type of foot arching diverse with respect to gender?
3. Are there differences in the linear measurements of feet in children in the pubertal phase of development?
4. What are the correlations between the type of body build and the arching of the feet of the tested pupils?

RESEARCH HYPOTHESES:

1. Younger children, regardless of age, are characterised by similar measurements of the length and width of feet (10-11).
2. Gender and age differentiate the arches of the feet.
3. During puberty, gender differentiates the linear measurements of feet and their arches.
4. There are essential correlations between the type of body build and the type of arches of the feet.

MATERIAL AND METHOD

The research of the somatotype and arches of the feet was conducted among children and youth from the region of Podkarpacie. It covered in total 181 children from Primary

School in Zarzecze, the Przeworsk poviat, including 79 boys and 102 girls, aged from 10 to 16. All the tested people remained in the adolescence phase, however at different stages of its development. The pupils were divided into two age groups, with consideration given to their gender and developmental phase. The group of 10-11 was in the prepubertal phase, while the group of 12-16 in the pubertal phase proper [Malinowski A. 2004]. As the differences in the body build are strongly shaped during puberty and as throughout the first decade of their life, in terms of their measurements and body mass, boys and girls are similar to each other [Wolański N. 2006], the following test groups were created:

1. Group one: boys and girls at the age from 10 to 11.
2. Group two: boys and girls at the age from 12 to 16.

The age classification was performed in accordance with auxological indications, namely the children who were older than 10 years and 6 months were included in the group of 11-year-olds. A similar division applied to the other age groups [Jopkiewicz A., Suliga E. 2005.].

In accordance with the rules accepted in anthropometry, the following were performed:

1. Measurements of somatic features: height, body mass, skinfold, girths (the results allowed for the establishment of the body build) [Malinowski A., Bożiłow W. 1997; Carter J.E. L., Heath B.H. 1990).
2. For the assessment of the parameters and selected indices of foot arches, 2D Foot Cad Podoscan was used, allowing a computer analysis of the sole-side of the feet. Feet tests were conducted in both non-weight bearing and weight bearing conditions. Statistical analysis of the length and width was performed, the Clarke angle established and the Wejsflog index calculated.

The results obtained were analysed, with consideration to the basic measures of descriptive statistics and Spearman's rank correlation coefficient, with the difference significance at the level of $\alpha = 0.05$.

RESULTS OF THE RESEARCH

Table 1. Number of boys and girls tested, with regard to age groups

Age group	Gender		Total
	Boys	Girls	
10-11	35	46	81
12-16	44	56	100
Total	79	102	181

The study covered a group of 79 boys and 102 girls, aged 10-16. In both groups, girls constituted a slightly higher percentage (table 1).

Table 2. Types of body build of the tested pupils

Body build type	Age group									
	10-11					12-16				
	$\bar{x}$	s	min	max	V (%)	$\bar{x}$	s	min	max	V (%)
Boys										
Endomorphic	4.43	1.94	1.70	7.80	44	3.32	1.49	1.50	7.00	45
Mesomorphic	4.24	1.14	2.00	7.50	27	3.49	1.32	0.90	7.10	38
Ectomorphic	2.37	1.60	0.10	5.40	68	3.53	1.58	0.10	5.80	45
Girls										
Endomorphic	4.80	1.43	2.40	7.60	30	4.28	1.39	2.20	7.00	32
Mesomorphic	3.75	1.27	1.20	7.80	34	3.06	1.50	0.70	7.00	49
Ectomorphic	2.56	1.58	0.10	5.70	62	2.82	1.77	0.10	6.00	63

In the younger age group, the endomorphic type prevailed, both in the boys and in the girls. In the older group, however, the ectomorphic type prevailed among the boys, and the endomorphic one among the girls (table 2).

Table 3. Linear parameters and arches of the feet

Foot parameters	Boys								Girls							
	10-11				12-16				10-11				12-16			
	$\bar{x}$	*s*	*Min Max*	*V %*	$\bar{x}$	*s*	*Min Max*	*V %*	$\bar{x}$	*s*	*Min Max*	*V %*	$\bar{x}$	*s*	*Min Max*	*V %*
	Measurements performed in weight bearing conditions															
Foot length L [mm]	227.0	12.9	200 266	6	250.4	15.1	222 279	6	229.1	10.8	211 257	5	239.5	11.6	213 266	5
Foot length R [mm]	226.7	13.0	199 266	6	250.5	14.9	222 281	6	228.9	10.9	210 256	5	239.8	11.9	214 269	5
Foot width L [mm]	85.2	5.3	73 98	6	94.4	7.5	78 110	8	85.8	4.8	76 95	6	90.4	5.3	77 106	6
Foot width R [mm]	85.5	5.1	75 98	6	95.0	7.0	80 109	7	86.4	5.1	76 98	6	90.7	5.3	76 105	6
Wejsflog index L	2.67	0.12	2.45 2.89	4	2.66	0.10	2.45 2.91	4	2.7	0.10	2.46 2.89	4	2.65	0.10	2.39 2.93	4
Wejsflog index R	2.65	0.10	2.45 2.86	4	2.64	0.10	2.44 2.88	4	2.66	0.10	2.38 2.84	4	2.65	0.11	2.36 2.91	4
Clarke angle L	50.9	4.0	40 57	8	52.7	2.9	40 60	5	50.9	3.6	44 61	7	50.6	3.6	42 58	7
Clarke angle R	51.2	3.4	43 58	7	52.4	3.3	40 58	6	50.8	3.4	43 59	7	50.5	3.0	44 58	6
	Measurements conducted in non-weight bearing conditions															
Foot length L [mm]	226.2	12.5	205 258	6	249.7	13.5	220 275	5	229.3	11.0	210 253	5	238.4	11.7	217 263	5
Foot length R [mm]	226.2	12.8	202 259	6	249.2	13.0	222 274	5	228.9	11.1	208 252	5	238.4	11.9	216 264	5
Foot width L [mm]	84.9	5.2	75 95	6	93.7	6.5	80 109	7	85.9	5.2	76 96	6	89.8	5.3	80 103	6
Foot width R [mm]	85.4	5.3	75 96	6	94.9	6.1	82 108	6	86.1	5.4	74 98	6	90.0	5.5	79 103	6
Wejsflog index L	2.67	0.11	2.48 2.88	4	2.67	0.09	2,47 2,88	4	2.67	0.10	2.49 2.87	4	2.66	0.10	2.42 2.89	4
Wejsflog index R	2.65	0.11	2.46 2.88	4	2.63	0.10	2,43 2,82	4	2.66	0.11	2.43 2.87	4	2.65	0.10	2.43 2.83	4
Clarke angle L [°]	51.7	4.8	43 68	9	52.1	3.1	40 58	6	49.6	3.6	43 60	7	50.7	3.0	45 58	6
Clarke angle R [°]	51.6	4.7	43 67	9	52.0	3.7	41 59	7	50.1	3.5	42 62	7	51.2	3.0	44 58	6

L- left foot, R-right foot

The length and the width of the feet of the boys and girls in the first age group showed similar parameters (in mm), however in the older groups, there was a bigger differentiation of the length and the width of the foot (approximately 11 mm in the length in the case of the boys, who were also a group in which a bigger (by 4.3 mm) width was noticed – that applies to right foot). The Wejsflog index calculated informs about the lack of transversal flattening of the foot in both the boys and the girls from the younger and older group. In the older group of boys, a tendency was noticed to rising of the medial, dynamic arch of the foot (Clarke angle) with its normal values, within the upper limit of normal (table 3).

The aforementioned results indicate a small differentiation between the measurements of the length and the width of the left foot, both in weight bearing conditions and in non-weight bearing conditions. Consequently, in order to look for a correlation between the body

build type and the arches of the foot, the analysis of the right foot in weight bearing conditions was considered (table 4,5).

Table 4. Body build types vs arches of the foot in boys

Body build type	**Age group**							
	10-11				**12-16**			
	Wejsflog index R in weight bearing conditions		Clarke angle R (in weight bearing conditions)		Wejsflog index R in weight bearing conditions		Clarke angle R (in weight bearing conditions)	
	R	p	R	p	R	p	R	p
Endomorphic	-0.33	**0.049***	-0.04	0.838	-0.08	0.606	+0.15	0.342
Mesomorphic	-0.54	**0.001***	-0.14	0.443	-0.41	**0.006***	+0.08	0.620
Ectomorphic	+0.41	**0.019***	+0.04	0.837	+0.24	0.118	-0.01	0.974

symbol* indicates the rejection of the null hypothesis with α =0.05, R- right foot

In the younger age group of boys, in every body build type the null hypothesis was rejected, while in the case of older boys, only in the mesomorphic type (table 4).

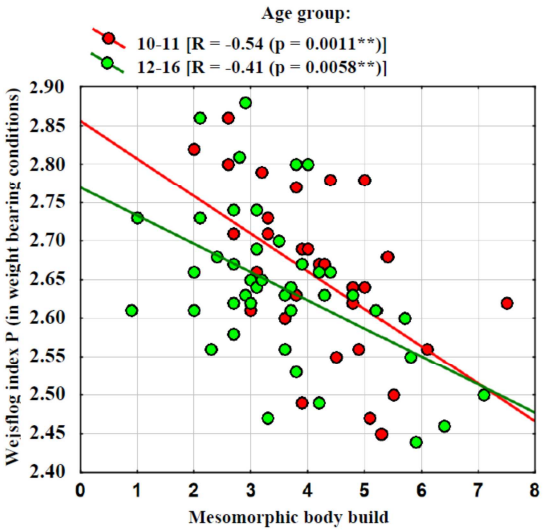

Figure 1. Correlation between the mesomorphic body build and the Wejsflog index

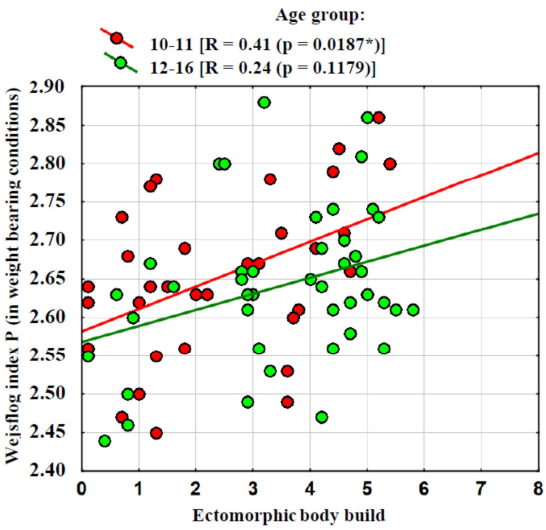

Figure 2. Correlation between the ectomorphic body build and the Wejsflog index

The minus sign (Fig. 1) indicates the opposite relationship between the mesomorphic body build and the Wejsflog index, while the plus sign (Fig. 2) indicates a direct relationship between the ectomorphic body build and the Wejsflog index.

Table 5. Body build types vs arches of the foot in girls

Body build type	**Age group**							
	10-11				**12-16**			
	Wejsflog index R in weight bearing conditions		Clarke angle R (in weight bearing conditions)		Wejsflog index R in weight bearing conditions		Clarke angle R (in weight bearing conditions)	
	R	p	R	p	R	p	R	p
Endomorphic	-0.26	0.087	+0.04	0.775	-0.68	**0.000***	+0.21	0.128
Mesomorphic	-0.36	**0.013***	-0.08	0.599	-0.66	**0.000***	+0.14	0.311
Ectomorphic	+0.36	**0.014***	+0.09	0.572	+0.68	**0.000***	-0.18	0.193

symbol* indicates the rejection of the null hypothesis with α =0.05, R- right foot

In the girls' group, the correlations were of a similar character as in the boys' group, with the difference being that much stronger correlations appeared in the older group. For girls aged 10-11 the strength of the correlation of body build indices with the transversal arch is slight, while in the age group 12-16 – quite large. Additionally, in this age group, the correlations are highly significant statistically, so the results are very reliable (table 5).

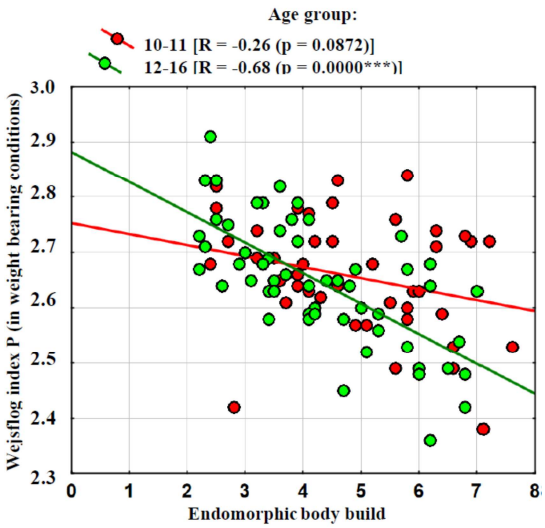

Figure 3. Correlation between the endomorphic body build and the Wejsflog index

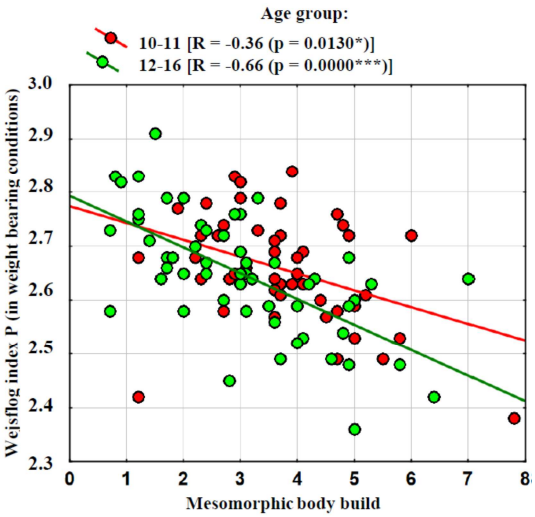

Figure 4. Correlation between the mesomorphic body build and the Wejsflog index

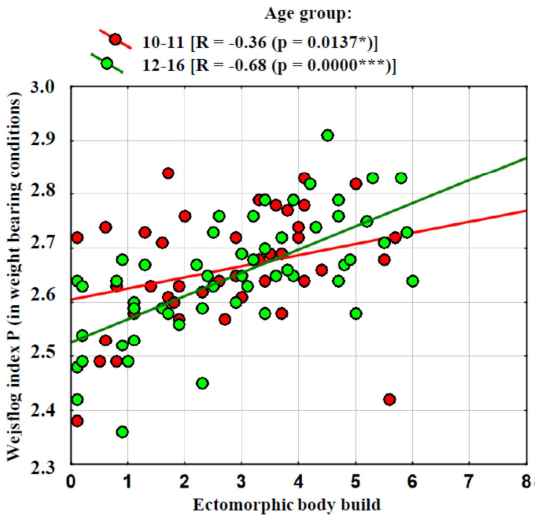

Figure 5. Correlation between the ectomorphic body build and the Wejsflog index

The minus sign (Fig. 3, Fig.4) indicates the opposite relationship between the endomorphic and mesomorphic body build and the Wejsflog index, while the plus sign (Fig. 5) indicates a direct relationship between the ectomorphic body build and the Wejsflog index "W".

DISCUSSION

The research of the body build type and the arches of the feet covered in total 181 boys and girls. The younger participants (10-11) were characterised by the endomorphic type of body build, which shows the tendency to adiposity. In older children, during puberty, the

endomorphic type (in girls) was proved to be the mode, while the boys were characterised by the ectomorphic type. Similar findings were shown in the research by Górniak K., Lichota M., Popławska H., Dmitruk A [2014]. The results of the authors' own study show that the build of the feet in the case of younger children does not differ in the linear parameters and the values of the indices (in weight bearing and non-weight bearing conditions), however the higher linear measurements as well as Clarke angle apply to the older boys (the Clarke angle for the right foot was 52.4) (table 3). On average, the feet of the boys in the older group were longer than the girls' feet by approximately 11 mm (the boys 250.5, the girls 239.8). They were also noticed to be wider by 4.3 mm – that concerns the right foot (boys 95.0, girls 90.7). In their publications, authors confirm that the growth of feet reveals changes together with age; it happens to have periods of intensive growth and certain slowdowns related to the shaping of the arches [Demczuk – Włodarczyk E. (2003); Łuba R., Olejniczak Z., Woźniak B. (2014); Rykała J., Snela S., Drzał – Grabiec J., Podgórska J. et al. (2013)]. Demczuk – Włodarczyk E. [2003] states that the differentiation of the morphological build of the male and the female foot, in the course of its ontogenesis, does not intensify at a constant rate, and it is most evident after puberty. The features of morphological build of the feet being shaped are dimorphicly distinct [Demczuk – Włodarczyk E. (2003); Łuba R., Olejniczak Z., Woźniak B. (2014)].

The measurements of the tested foot features performed in weight bearing conditions and in non-weight bearing conditions were not statistically significant. Due to that, in order to look for a correlation between the body build type and the longitudinal and transversal arches of the foot, the measurements of the right foot, performed in weight bearing conditions were considered (table 4, 5).

The results of the authors' own research of the longitudinal and transversal arches of the foot indicate lack of abnormalities in their structure. Similar results have been presented by Leszczak J., Drzał – Grabiec J., Rykała J., Podgórska – Bednarz J. et al. (2014); Rykała J., Snela S., Drzał – Grabiec J., Podgórska J. et al. (2013). However, based on the authors' own observations, there can be noticed a tendency to rising of the medial – dynamic arch of the foot, with its values being normal, however close to the upper limit of normal – that applies to the boys. Similar observations have been presented by Demczuk – Włodarczyk E. (2003), Rykała J., Snela S., Drzał – Grabiec J., Podgórska J et al. (2013).

Analysing the relationships between the body build type and the Clarke angle for the right foot, no significant correlation was found. That is confirmed by the results of the study by Trzcińska D., Olszewska E. [2005]. Contrary to the general belief that the feet of the types with a massive body build are characterised by the lowest longitudinal arch [Dowling A.M., Steele J.R., Baur L.A. (2001); Mickle K.J., Steele J.R., Munro B.J. (2006); Górniak K. Lichota M., Popławska H., Dmitruk A. (2014)].

E. Demczuk – Włodarczyk [2003], on the basis of the results of her research, noticed an occasional occurrence of a flat foot, assuming that in the period of progressive development, a massive body build only worsens, yet does not disturb the development of the longitudinal architecture of the foot. A common occurrence of a fallen transversal arch in people with a massive body build inclines us to consider that factor as one that particularly disturbs the transversal architecture of the feet. The author of the research found a significant correlation in the group of boys. In the girls' group, despite lack of significant correlation, the fall of the transversal arch occurred more often in the massive and slim body build type.

Those opinions are confirmed by the results of the authors' own research, which revealed that the endomorphic and mesomorphic body build type affects the lowering of the transversal arch.

The results obtained and their analysis and interpretation may constitute the basis for further scholarly publications. What is essential is to grasp the stage of musculoligamentous impairment, which should result in appropriate corrective treatment.

CONCLUSIONS

Based on the research results that were obtained, the following conclusions could be formulated:

1. At the age of 10-11, the linear measurements of feet are similar, regardless of the gender.
2. Gender and age do not differentiate the transversal arches of the feet.
3. During puberty, a differentiation concerning the length and width of the feet takes place, with regard to the gender of the tested people.
4. The body build type affects the transversal arch of the feet, both in the boys and in the girls tested, assuming a varied direction of relationship.

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