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THE ANALYSIS OF FEET CONSTRUCTION VERSUS BMI IN 8-YEAR-OLD BOYS

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Abstract

Introduction. The foot due to its complex structure provides three basic functions: supportive, locomotive and amortization. The human foot is an important static-dynamic part of the motor system. A properly shaped foot should be supported by three points: the first and the fifth metatarsal bone and the external part of the heel.

Purpose of research. The aim of the study was to analyze the feet construction and find the relationships between the foot structure parameters and BMI among 8-year-old boys.

Material and methods. The study involved 85 boys. The weight and the body height of the children were measured, body mass index was calculated, and the footprint using the was made. On the basis of the foot picture, the basic parameters for foot assessment as well as

relations between these indicators and BMI were calculated. Subsequently, the Clarke angle, the hallux valgus angle and Wejsflog index were determined in manual way. Then the dependency between these parameters and BMI was investigated.

Results. The number of lower foot arch or flat foot in the study group amounted to 53%, the transverse flat foot was observed among 17% of the studied boys feet and the hallux valgus angle beyond the norm occurred in 9% of the studied feet. There is a relationship between the Clark's angle, Wejsflog index, hallux valgus angle α and BMI of boys.

Conclusions. Boys with a higher BMI have lower values of the Clark angle and the Wejsflog index which are the evidence of a lower longitudinal and transverse arch. Children with higher BMI have higher values of the angle of hallux valgus α

Keywords: foot arch, foot structure, children, BMI.

Introduction

The foot because of its complex structure provides three basic functions: supportive, locomotive and amortization. The human foot is an important static-dynamic part of the motor system. During its development it has to undergo several adaptations for carrying large and dynamic loads. A properly shaped foot should be supported by three points: the first and the fifth metatarsal bone and the external part of the heel. The foot efficiency primarily depends on properly shaped longitudinal and transverse arches. Improperly formed feet can be a source of problems in an everyday life. Therefore, assessing the feet arches is an important part of diagnosing for preventive and corrective actions [1]. To fulfill the amortization function, the foot should be properly shaped. There are three arches in the foot structure, two longitudinal - lateral and medial and one transverse. The shortest of them is a transverse arch and the longest longitudinal – a medial arch. Any arch disorders – such as its flattening or deepening from the biomechanical point of view –results in a uneconomical gait, run or jump. Any overload pathologies in the foot' structure may cause problems not only in the foot inself, but also in other parts of the body [2].

Purpose of research. The aim of the study was to analyze the foot construction and find the relationships between the basic foot structure parameters and BMI among 8-year-old boys.

Material and methods

The study was conducted in the primary schools in 2015 and involved 85 boys. The study was carried out, after obtaining the parents' consents. The body weight of the children was measured the Tanita device with accuracy of 0,1 kg and the body height was measured with the use of SECA with accuracy of 0,01 m. Then the BMI index was calculated. The photo of the plantar surface of the foot was taken with the 2D podoscanner. The children were examined in their underwear without shoes and socks, the child was standing on the podoscan at full load. In the foot print the computer program calculated the basic feet parameters, and subsequently determined the Clark angle, hallux valgus angle α and Wejsflog index in manual way. The Clark angle is a parameter which serves to evaluate the longitudinal arch of the foot. The norms presented by Kasperczyk [1] and Wilczynski [3] were used in the. The standards of 0-9 ° [1, 3] were adopted for hallux valgus angle α. Wejsflog index evaluates the transverse arch of the feet and it is the proportion of the foot length to its width. The aspect proportions should be 3: 1 the values closer to 2 indicate transverse flat feet, whereas those closer to 3 - properly shaped feet [1, 3]. In the present study, it was assumed that the result up to 2,5 means transverse flat feet whereas above 2,5 – properly shaped feet. For analysing the research the author used MS Office Excel and R.3.3.1 statistical program. For all parameters the basic measures of descriptive statistics, i.e. mean, standard deviation, minimum and maximum values were used. To examine the relationships the author used nonparametric tests – namely Spearman's rank correlation analysis. When the level of statistical significance equaled $p < 0.05$. Table 1 presents the main characteristics of the boys' study group.

Table 1. Characteristics of the study group

Parameter	Mean	Minimum	Maximum	Standard deviation
Body height	1.26	1.17	1.46	0.04
Body mass	26.35	18.00	43,00	5.43
BMI	16.23	11.90	27.75	2.72

Results

Table 2 provides the information of selected feet construction parameters and the basic measures of descriptive statistics characterizing them.

Table 2. Selected parameters characterizing the feet construction, arithmetic mean, minimum, maximum, standard deviation

Parameter	Mean	Minimum	Maximum	Standard deviation
Foot length L	197.75	173,00	225.00	10.96
Foot length P	197.59	174.00	225.00	10.77
The width of the forefoot L	75.76	63.00	90,00	4.68
The width of the forefoot P	76.01	67.00	91.00	4.65
Wejsflog index L	2.60	2.37	2.80	0.09
Wejsflog index P	2.60	2.37	2.98	0.09
The Clarke angle L	41.21	20.00	55.00	5.89
The Clarke angle P	40.23	18.00	53,00	6.09
Hallux valgus angle α L foot	5.67	0.00	15,00	3.25
Hallux valgus angle α P foot	4.32	0.00	14.00	3.19

Table 3, 4, 5 refer to the selected parameters characterizing the feet structure and divide the feet structure division due to these parameters according to the norms provided by Kasperczyk [1] and Wilczyński [3].

Table 3. Longitudinal arch evaluated by the Clarke angle in the study group

Clark's angle	Number of feet	Feet percentage
Flat foot	5	3%
Normal foot	79	46%
Lower arch of foot	85	50%
Higher arch foot	1	1%

Table 4. Transverese arches of feet in the study group with regard to Wejsflog index

Wejsflog index	Number of feet	Feet percentage
Transverse flat foot	29	17%
Normal foot	141	83%

Table 5. Hallux valgus angle in the study group

Hallux valgus angle α	Number of feet	Feet percentage
Beyond the norm	16	9%
Normal values	154	91%

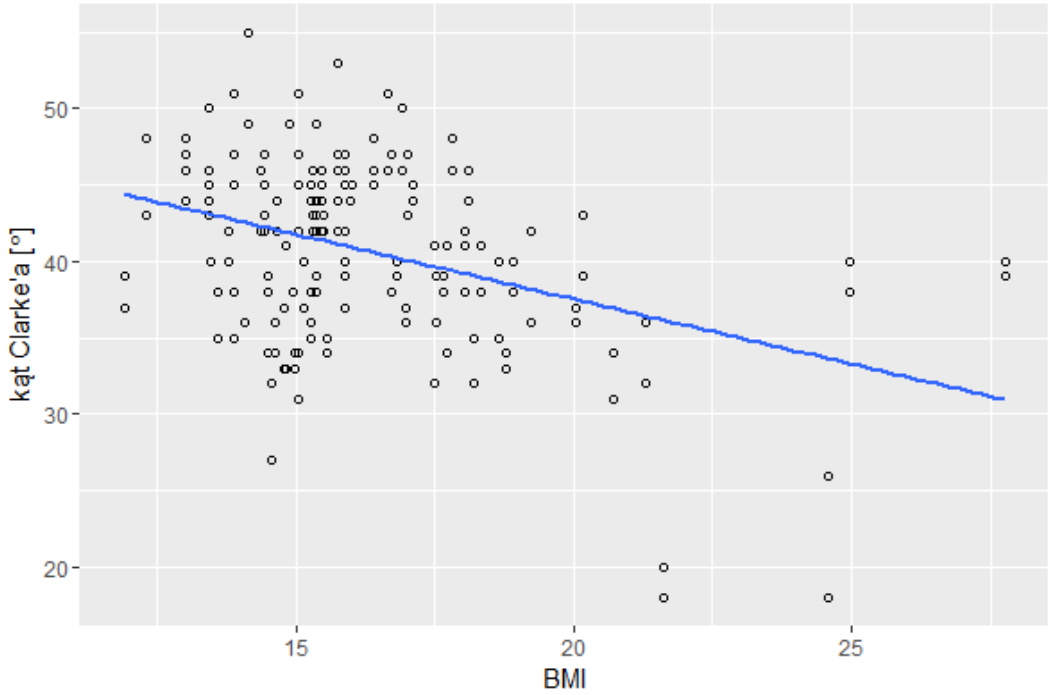

Figure 1. The relationship between the Clark angle and BMI

Spearman's rank correlation analysis demonstrated that there was a statistically significant negative relationship between BMI and the Clarke angle (ρ = -0.25; p-val = 0.001) (Figure 1).

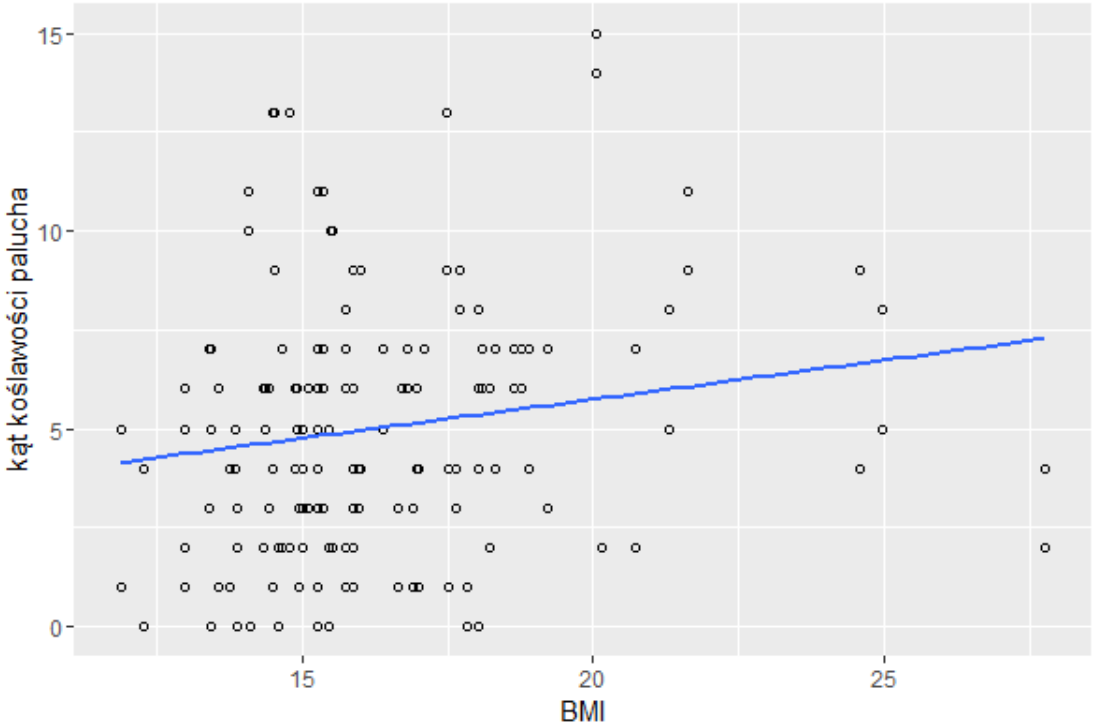

Figure 2. The relationship between hallux valgus angle and BMI

Spearman’s correlation analysis revealed a statistically significant positive relationship ($\rho = 0.21$, p-val = 0.005) (Figure 2).

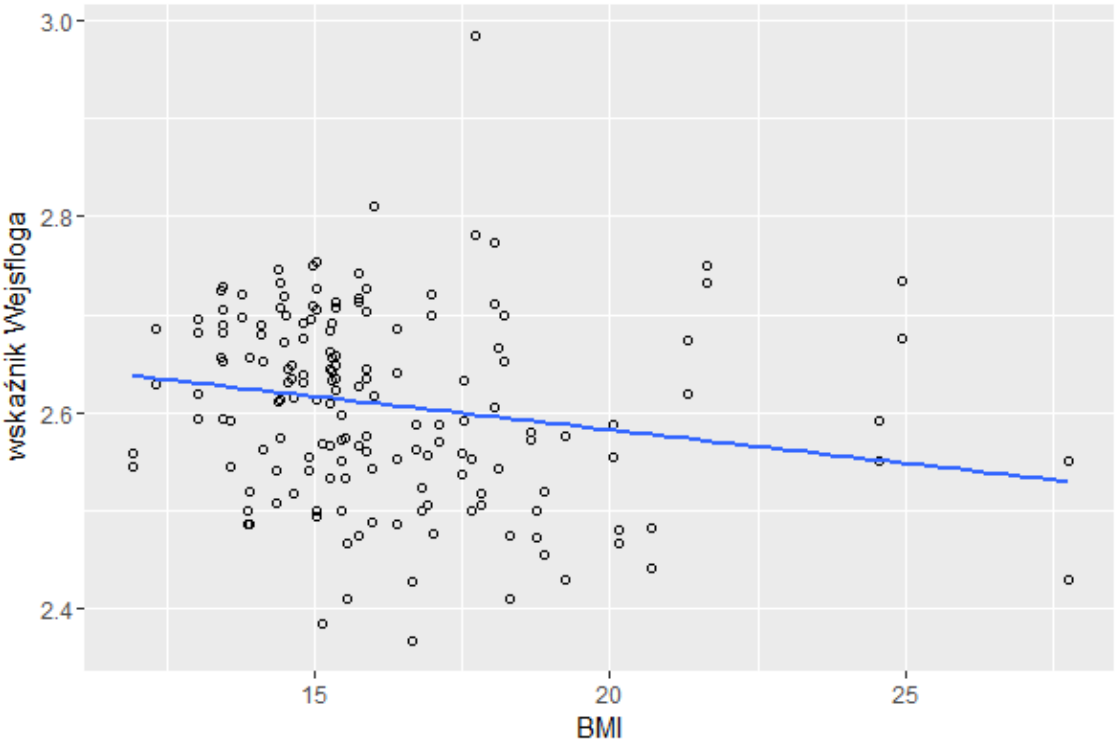

Figure 3. The relationship between Wejslog index and BMI

Spearman’s correlation analysis showed the existence of a statistically significant correlation between BMI and Wejsflog index ($\rho = -0.26$, p-val <0.01) (Figure 3).

Discussion

During the body posture development, including the children's feet structure, two critical moments are of great importance. The first is the moment when a child goes to pre-school, after the period when the child was engaged in games and play and now begins a more sedentary lifestyle. The next period is the age of puberty, which comes slightly earlier in girls than in boys. During these periods, special attention should be paid to the somatic posture of children in order to prevent the emergence of new or consolidation of already existing body posture deformities [1]. In literature one may find different ages when the formation of the foot structure among children is finally finished. The authors reported that it is the age of 10-12 [1] up to 15-16 years old [4, 5].

Evaluation of the foot structure for physiotherapy procedures is an important element for patients of all ages. The tool, which was used for this study allows accurate monitoring and evaluation of the foot posture. The effectiveness of the foot structure assessment with the use of this method is confirmed by Mosór, Kromka-Szydek and Mikołajewska [6, 7, 8]. Also, in the opinion of the authors of this publication the podoscanner is a useful tool in practical clinic which might be applied to assess and monitor the effects of treatment of the patients of all ages.

In the study group, the mean values of Wejsflog index, hallux valgus angle α remain within the limits presented by Kasperczyk [1] and Wilczyński [3]. The mean values of the Clark angle were slightly lower than the norm presented by these authors, this standard falls within the limits of 42-54 °, but the children's foot at the age of the study group is still being formed, so it can be assumed that the longitudinal arch has not been fully developed yet. However, it is necessary to pay attention to the foot formation process among those boys. It is important to educate parents and to draw their attention to the problem of the flat feet among children. In the presented study more than a half of the boys' feet were with low arch or flat feet (53%). Transverse flat feet evaluated using Wejsflog index amounted to 17% and hallux valgus angle α was found beyond the norm among 9% of the boys' foot. As BMI increases, the values of Wejsflog index, hallux valgus angle α increase too and the values of the Clark angle decrease. It may suggest that when BMI is higher (overweight and obese children), the longitudinal and transverse arches are lower and the values of hallux valgus angle α are higher.

Jankowicz-Szymańska and Pociecha [9], while examining slightly younger children, observed that the longitudinal arch, which was also assessed using the Clark angle, was slightly lower in boys than in girls. Maybe due to that fact in the present study the mean value of the Clark angle among boys was slightly below the norm. As in the study group presented in herein, the relationship between BMI and the Clark angle was found. Puszczałowska-Lizis et al. [10] also found a correlation between the increase body weight and the Clark angle among the studied children from the second grade. The authors observed more frequently lower values of Clark angle in boys than in girls. Pauk et al. [4] and Puzder et al. [11] in their studies also observed that lower longitudinal arch of the foot correlated with the increase body weight or higher BMI. Also Evans [12] who examined children aged between 7-10 in Australia stated that higher BMI providing evidence of overweight or obesity reduces the longitudinal arch of the foot. However, there were also publications in which this relationship was not observed [13, 14].

Similar to the studies of Klimczak et al. [15] approximately a half of the feet was properly formed, but in those studies the number of flat feet was much greater than in the present study.

The evaluation of the foot structure is an important part of physiotherapy treatment and a crucial aspect at every stage of our life, as prevention is of great importance in case of every postural deformity.

Conclusions

1. Boys with higher BMI, have lower values of the Clark angle and Wejsflog index, which is an evidence of lower longitudinal and transverse arch.
2. Boys with higher BMI have higher values of hallux valgus angle α.

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