

Analysis of foot structure in pre-school children

Beata Szczepanowska-Wołowiec^{1, 2, A,B,C,D,E,F}, Paulina Sztandera^{3, A,B,C,D,E,F}, Ireneusz Kotela^{1, D,E,G}

¹ Jan Kochanowski University in Kielce, Faculty of Medicine and Health Sciences, Department of Rehabilitation in Musculoskeletal Disorders. Head: Prof. Ireneusz Kotela, MD, PhD

² District Hospital, Department of Rehabilitation. Head: Grażyna Ściegienna-Zdeb, MD

³ Jan Kochanowski University in Kielce, Faculty of Medicine and Health Sciences, postdoctoral studied, Dean-Prof. Marianna Janion, Md, PhD

Introduction

The foot is a complex biokinematic structure and an important part of the static-dynamic musculoskeletal system. Its supportive, weight-bearing and locomotor functions are essential. These tasks can be fulfilled when the morphological foot structure, particularly the shape of longitudinal and transverse arches, are normal. During various stages of development, the foot structure undergoes changes, whose intensity varies. In infancy, the foot is covered by the soft adipose tissue and the process of ossification is poorly advanced. Therefore, this period is characterised by physiological platypodia. When infants aged about one year assume the erect position, locomotion is the major factor involved in shaping the structure of feet. At the age of 3-4 years, the internal plantar foot arch starts to be shaped. The transverse and longitudinal arches are observed in six-year old children, albeit the process is continued. The pres- and early-school period is characterised by large changes within the foot. The analysis of foot structure in pre- and early-school children is essential for prevention or treatment of disorders, whenever required [1,2,3].

The objective of the present study was to evaluate the foot shape in pre-school children.

Material and methods

The study included 29 pre-school children from the kindergarten in Masłów (Świętokrzyski

province). The study population consisted of 15 girls and 14 boys. The study designed was approved by the Bioethics Committee at the Faculty of Medicine and Health Sciences, Jan Kochanowski University in Kielce. Moreover, the kindergarten headmaster, as well as parents or care minders gave the informed consent for participation of their children in the study.

The inclusion criteria involved the age of 3-6 years, no history of orthopaedic diseases, consent for participation and proper evaluation.

The exclusion criteria were as follows: ages different than 3-6 years, orthopaedic diseases, lack of consent and improper evaluation.

The weight and height were measured and BMI calculated. The next step was to X-ray feet using Podoscan 2D. The pictures of bare and fully loaded feet were taken. The basic parameters for morphological evaluation of feet were determined using computer analysis.

The data analysed included gender, age, weight and height, foot length, forefoot width, Clarke's angle and Wejsflog's index. Both feet were examined. The results were analysed using MS Office Excel and statistical software R.3.3.1. The descriptive statistics were used, i.e. arrhythmic mean, standard deviation, minimum and maximum for the entire group and gender-matched subgroups. Inter-variable correlations were tested using the Spearman's rank correlation analysis. $P < 0.05$ was considered statistically significant.

Results

In the study population, the mean age was 5.16, body weight 18.49, height 1.09 and BMI 15.58 (table 1).

The foot parameters were presented in table 2. The mean left (L) foot length was 171.27 while the mean right (R) foot length was 171.09; the mean L forefoot width was 67.83 and the mean R forefoot

width was 67.52; moreover, the mean Clarke's angles were 44.78 and 43.85 for the left and right foot, respectively whereas the mean Wejsflog's indices - 2.54 and 2.51 for the left and the right foot, respectively. The differences in the length and width between the left and right foot were not found to be statistically significant.

Table 1. Characteristics of the study population

Parameter	Gender	Mean	Minimum	Maximum	Standard deviation
Height	Girls	1.08	0.96	1.17	0.05
	Boys	1.10	0.90	1.20	0.07
	Total	1.09	0.90	1.20	0.06
Body weight	Girls	18.12	13.00	22.00	2.44
	Boys	18.86	14.00	30.00	4.10
	Total	18.47	13.00	30.00	3.30
BMI	Girls	15.58	13.00	18.84	1.50
	Boys	15.58	11.15	21.54	2.37
	Total	15.58	11.15	21.54	1.94

Table 2. Basic study parameters

Parameter	Gender	Mean	Minimum	Maximum	Standard deviation
L foot length	Girls	168.72	150.00	185.00	10.47
	Boys	174.00	150.00	190.00	11.04
	Total	171.27	150.00	190.00	10.90
R foot length	Girls	168.87	150.00	186.00	10.85
	Boys	173.50	148.00	191.00	12.34
	Total	171.09	148.00	191.00	11.63
L forefoot width	Girls	67.07	58.00	72.00	4.01
	Boys	68.63	61.00	73.00	4.00
	Total	67.83	58.00	73.00	4.02
R forefoot width	Girls	66.60	58.00	73.00	4.07
	Boys	68.50	62.00	73.00	3.59
	Total	67.52	58.00	73.00	3.90
L foot Clarke's angle	Girls	45.72	36.00	54.00	4.76
	Boys	43.78	33.00	49.00	5.69
	Total	44.78	33.00	54.00	5.23

Parameter	Gender	Mean	Minimum	Maximum	Standard deviation
R forefoot Clarke`s angle	Girls	43.87	35.00	52.00	3.43
	Boys	43.86	30.00	49.00	4.96
	Total	43.85	30.00	52.00	4.15
L foot Wejsflog`s index	Girls	2.52	2.42	2.65	0.06
	Boys	2.53	2.37	2.68	0.09
	Total	2.54	2.37	2.68	0.07
R foot Wejsflog`s index	Girls	2.52	2.40	2.61	0.05
	Boys	2.53	2.40	2.70	0.08
	Total	2.51	2.40	2.70	0.06
L foot hallux valgus angle	Girls	5.60	1.00	14.00	4.00
	Boys	5.70	2.00	15.00	3.30
	Total	5.65	1.00	15.00	3.63
R foot hallux valgus angle	Girls	4.80	1.00	13.00	3.57
	Boys	5.20	1.00	9.00	2.28
	Total	5.00	1.00	13.00	2.96

A statistically significant correlation was observed between the difference in foot length and age. The older the pre-school child, the bigger the right foot length, as compared to the left foot - the Spearman`s correlation $\rho = 0.40$, $p\text{-val} = 0.03$ (Fig.1).

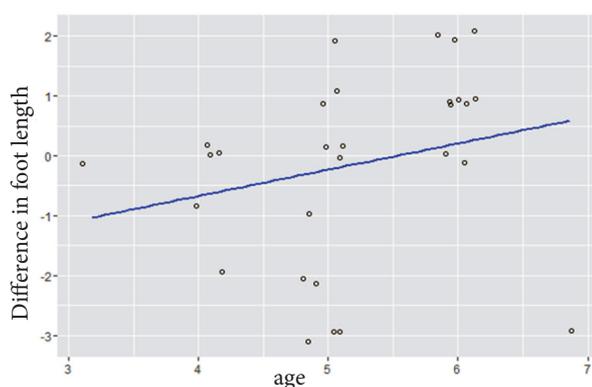


Fig. 1. Correlation between the foot length and age

Analysis of the Clarke`s angle versus age did not demonstrate statistical significance. Analysis of the Wejsflog`s index versus age revealed a positive statistically significant correlation. The older the pre-school child, the higher the Wejsflog`s index (Fig.2).

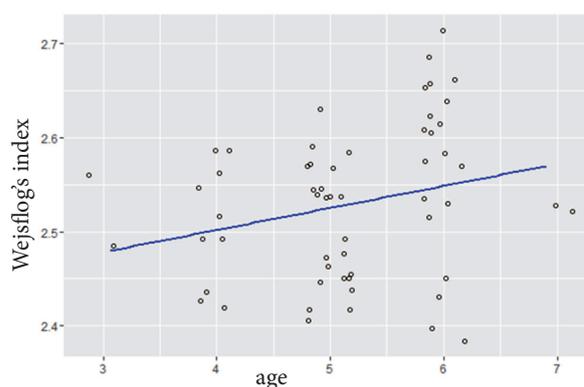


Fig. 2. The Wejsflog`s index versus age

Analysis of the hallux valgus angle and age did not show any statistically significant correlation between them..

Likewise, correlations among the Clarke`s angle, age and gender and BMI were not statistically significant.

A negative statistically significant correlation was found between BMI and the Wejsflog`s index (Fig.3).

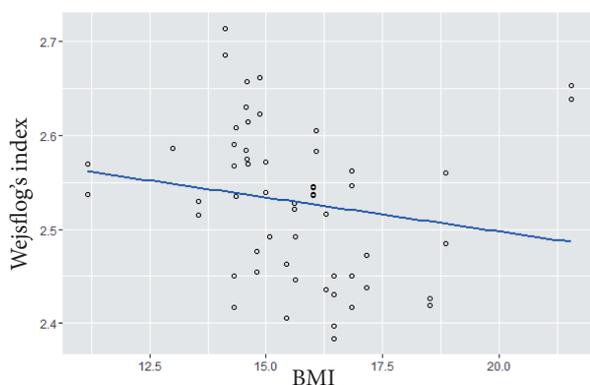


Fig. 3. Correlation between the Wejsflog's index and BMI

There was no significant correlation found between the Wejsflog's index and gender.

Otherwise, a positive significant correlation was observed between age and the Wejsflog's index. The older the pre-schoolchild, the higher the values of Wejsflog's index (Fig 4).

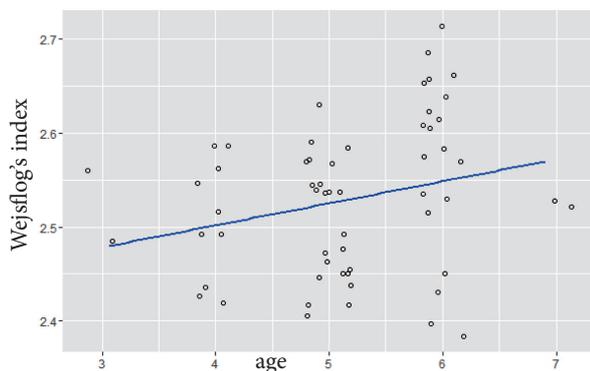


Fig. 4. Correlation between the Wejsflog's index and age

No statistically significant differences were found between the right and left foot length and width.

Discussion

Foot deformities occurring in children and teenagers are relatively common. The proper development of feet may be limited by the lack of unrestrained movements of toes in too tight socks or shoes. Moreover, too early initiation of walking before the child has assumed the erect position

can negatively affect the development of feet and body posture. Genetic predispositions were also found relevant for foot development. The majority of newborns have healthy, properly built feet. The pre-school period is characterised by the intense development during which the height and body weight increase, considerably affecting proper foot shapes [4].

Our findings demonstrated that the foot structure in pre-school children was normal. Similar observations were reported by Waclawek [2] and Mrozkowiak [5]. Waclawek [2] has observed differences in foot length and width between the right and left foot. Our results were comparable, yet were not found to be statistically significant. However, with age the difference between the right and left foot increased, **with the right foot predominance**.

Micke [6] has found lower foot arching among boys, as compared to girls. Likewise, according to Jankowicz-Szymańska[7] the values of Clarke's angle in boys were lower; similar relationships were observed in our study. The statistically non-significant correlation between the Clarke's angle and gender observed by us is most likely associated with the small size of the sample analysed in the study.

Moreover, the Wejsflog's index in our study population was normal. Similar observations were reported by Waclawek [2]. Our findings demonstrated the correlation between the Wejsflog's index and BMI of children; the higher the BMI, the lower the transverse arch of the foot.

Furthermore, our results showed no statistically significant correlation between the hallux valgus angle versus gender and age of children. The mean values of the angle were within normal limits. Different results were reported by Klein [8].

Our study population was small; therefore, further studies are required involving larger populations of children.

Conclusions

1. The foot structures in pre-school girls and boys are normal.
2. The values of Clarke's angle are lower among boys compared to girls.
3. There is a statistically significant correlation between the Wejsflog's index and age.
4. **Further research is required.**

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