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The feet construction of 9-year-old children

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Abstract

Introduction and purpose of the work, The human foot it is a very complex structure of the body, as it contains 26 bones, 19 muscles and 33 joints. Because of the cooperation all of those elements, the foot could fulfillthree basic functions such as load, amortization and locomotive functions. The aim of this research was to evaluate the feet construction in 9-year-old children from Masłów and Górno District.

Material and method, The study involved 168 9-year-old children. There were 89 (53%) and boys 79 (47%) in the study group. The study was conducted in 2015/2016. The children were examined in schools after prior permission given by principals and parents or legal guardians. The body weight of the children was measured using the Tanita device and the body height was measured with the use of SECA. Then, the BMI index was calculated and compared to Centil grid presented in Olaf study. The plantar part of the foot was evaluated by 2D podoscanner. The relationship between the chosen parameters, sex and BMI was calculated. To examine the relationships, the author took advantage of nonparametric tests - Spearman's rank correlation analysis, Manna-Whitneya-Wilcoxona test and χ^2 test. When the level of statistical significance equaled $p < 0.05$.

Results. Almost half of the examined feet reached the values of Clark angle which are an evidence of lower arch or flat feet. Transverse flat feet occurred in 15% cases, hallux valgus angle α beyond the norm was examined in 8% of feet. There was no statistically significant relationship between BMI and Clark angle or hallux valgus angle α. Normal values of Clark

angle occurred more often in girls' feet. In the study group there was no statistically significant relationship between Wejsflog index,hallux valgus angle α and BMI.

Conclusions

In study group there is no statistically significant relationship between BMI and Clark angle. The girls in the study group more frequently had normal values of Clark angle. Wejsflog index is slightly higher in girls' feet. Children with higher BMI have lower values of Wejsflog index, which is an evidence of lower longitudinal and transverse arch. In the study group there was no statistically significant relationship between BMI, sex and hallux valgus angle α.

Key words. longitudinal arch, transverse arch, feet.

Introduction.

The human foot it is a very complex structure of the body, as it contains 26 bones, 19 muscles and 33 joints [1]. Because of the cooperation all of those elements, the foot could fulfillthree basic functions such as load, amortization and locomotive functions. It is important to support the foot while standing and walkingon three points: the first and the fifth metatarsal bone and the external part of the heel [2].

To fulfill the amortization function, the foot has three arches: two longitudinal – lateral and medial and one transverse. The longest one is a longitudinal medial arch and the shortest – a transverse arch. Properly shaped arches ensure resilience and smoothness of the walk, and thus, the foot could adaptto different grounds. Foot deformities like flattening the arch are the cause of a less effective walk, run and jump [3]. When the child starts to stand up for the first time, the process for foot shaping is initiated as well. It is important not to speed up this process. The final process of shaping arches is claimed differently by authors. Kasperczyk [2] maintained that age is when a child is 10-12 years old, but Pauk at. all [4] noticed that the final processtakes place at the age of sexual maturation: 10-15 in girls and 13-15 in boys, this age is similar to Volpon's [5] observations.

The evaluation of the foot shape is an important part of physiotherapy treatmentof both children and adults. There are two evaluation methods: subjective and objective. The subjunctive methods include observation, conducting an interview and feet efficiency tests . The objective methods are: X-ray, ultrasonography, Moire method, computed tomography, Magnetic resonance imaging, plantoconturography. Plantoconturography is a method which could be conducted in a traditional way on the basis of the foot reflected on a piece of paper, with the use of the podoscanor the podoscanner. The podoscanner is connected with a computer, and the computer program gives the user information about basic parameters.Additionally,it is possible to designate parameters manually in the computer program [1]. The evaluation method should not be prejudicial to people's health. Taking the above into consideration, the podoscanner or podoscop is a better method than X-ray [6].

The purpose of work.

The aim of this research was to evaluate the feet construction in 9-year-old children from Masłów and Górno District.

Material and methods.

The study involved 168 9-year-old children from schools of Masłów and Górno District, which are situated in the Świętokrzyskie Voivodeship. There were 89 (53%) and boys 79 (47%) in the study group. The study was conducted in 2015/2016. The bioethical Commision of Jan Kochanowski University in Kielce gave their consent for the study. The children were examined in schools after prior permission given by principals and parents or legal guardians. The inclusion criteria to study was: the written agreement of parents or legal guardians, no destruction illnesses, and good health condition. The exclusion criteria included: no written agreement of parents or legal guardians or chronic diseases. The body weight of the children was measured using the Tanita device and the body height was measured with the use of SECA. Then, the BMI index was calculated and compared to Centil grid presented in Olaf study [7]. The plantar part of the foot was evaluated by 2D podoscanner. The computer program gave information about basic parameters such as: foot length, forefoot width, arch length, length, backfoot width. Subsequently, Clarke angle, Wejsflog index and hallux valgus angle α were manually determined. The evaluation of these parameters referred to the norms presented by Kasperczyk [2] and Wilczyński [8]. The relationship between the chosen parameters, sex and BMI was calculated. For statistical analysis of the research, the authors 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 took advantage of nonparametric tests - Spearman's rank correlation analysis, Manna-Whitneya-Wilcoxona test and χ^2 test. When the level of statistical significance equaled $p < 0.05$. Table 1 presents the main characteristics of the children' study group.

Table 1. Characteristics of the study group

Parameters	Sex	Mean	Minimum	Maximum	Standard deviation
Body height	Girls	1,35	1,20	1,63	0,07
	Boys	1,35	1,18	1,80	0,09
	Together	1,35	1,18	1,80	0,08
Body weight	Girls	31,67	19,00	52,00	8,15
	Boys	31,57	20,00	61,00	7,65
	Together	31,62	19,00	61,00	7,89
BMI	Girls	17,18	11,48	24,68	3,02
	Boys	17,15	13,21	23,63	2,60
	Together	17,17	11,48	24,68	2,82

Results.

The basic parameters of the foot structure, mean value, standard deviation, minimum, maximum are presented in Table 2. Mean values od Wejsflog index, hallux valgus angle are in norms presented by Kasperczyk [2] and Wilczyński [8]. Mean values of girls' Clark angle

fall within the presented norms, but according to the values found among boys - they are slightly below these norms.

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

Parametr	Sex	Mean	Minimum	Maximum	Standard deviation
Footlength L	Girls	208,90	172,00	255,00	15,67
	Boys	210,47	169,00	268,00	15,52
	Together	209,65	169,00	268,00	15,57
Footlength P	Girls	209,06	170,00	252,00	15,63
	Boys	210,52	176,00	270,00	15,44
	Together	209,75	170,00	270,00	15,51
The width of the forefoot L	Girls	78,50	66,00	94,00	6,07
	Boys	79,71	62,00	99,00	5,88
	Together	79,08	62,00	99,00	5,99
The width of the forefoot P	Girls	78,82	63,00	96,00	6,29
	Boys	80,38	63,00	100,00	5,84
	Together	79,56	63,00	100,00	6,10
The Clarke angle L	Girls	43,41	27,00	58,00	5,38
	Boys	41,95	30,00	56,00	5,54
	Together	42,72	27,00	58,00	5,50
The Clarke angle P	Girls	42,19	29,00	51,00	5,03
	Boys	40,85	29,00	51,00	4,79
	Together	41,56	29,00	51,00	4,95
Wejsflog index L	Girls	2,67	2,44	2,89	0,10
	Boys	2,63	2,40	3,57	0,15
	Together	2,65	2,40	3,57	0,14
Wejsflog index P	Girls	2,65	2,38	2,92	0,11
	Boys	2,61	2,33	3,48	0,16
	Together	2,63	2,33	3,48	0,14
Hallux valgus angle α L foot	Girls	5,26	0,00	13,00	3,39
	Boys	4,81	0,00	20,00	3,69
	Together	5,04	0,00	20,00	3,54
Hallux valgus angle α P foot	Girls	4,25	0,00	13,00	2,96
	Boys	3,47	0,00	10,00	2,84
	Together	3,86	0,00	13,00	2,93

Table 3, 4, 5 refer to the selected parameters characterizing the feet structure and divide the feet structure due to these parameters.

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

Clark'sangle	Number of feet	Feetpercentage
Flat foot	7	2%
Normalfoot	140	42%
Lower arch of foot	187	56%
Higherarchfoot	2	1%

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

Wejsflog index	Number of feet	Feetpercentage
Transverse flat foot	51	15%
Normal foot	285	85%

Table 5. Hallux valgus angle in the study group

Halluxvalgusangle α	Number of feet	Feetpercentage
Beyond the norm	27	8%
Normalvalues	309	92%

Table 6 evaluates the nutrition status of 9-year-old children according to the centile grid presented by Kułaga at all [7]

Table 6. Evaluation of nutrition status connected to BMI

BMI	Children	
Overweight	60	18%
Underweight	46	14%
Norm	230	68%
Obesity	0	0%

An analysis of the relationship between BMI and Clark angle in the study group showed that there is no statistically significant correlation.

Table 7 gives information about relationship and sex.

Tabla 7. Relationship between Clark angle and sex in the study group

Clarke angle	Girls		Boys		Together	
	N	%	n	%	n	%
Beyond the norm	65	37%	84	53%	149	44%
Norm	113	63%	74	47%	187	56%
Together	178	100%	158	100%	336	100%

χ^2 test revealed a statistically significant relationship between Clark angle and sex (χ^2=8.7, p =0.003). Normal values of Clark angle occurred more frequently in 9-year-old girls.

Manna-Whitneya-Wilcoxona test showed no relationship between BMI and hallux valgus angle α.

χ^2 test demonstrated that there was no statistically significant relationship between BMI and andWejsflog index (χ^2=0.23, p = 0.63)

Spearman's correlation analysis showed the existence of a statistically significant correlation between BMI and Wejsflog index (ρ=-0.18, p = 0.001). When BMI is higher, the value of Wejsflog index is lower.

Manna-Whitneya-Wilcoxona test showed a statistically significant relationship between sex and Wejsflog index (statystyka W = 16732, p = 0.003).Slightly higher values of Wejsflog index are found in the group of girls.

Discussion.

The foot evaluation is an important part of physiotherapy treatment in patients of all age. It is important to assess it in a fast, safe and objective way. The podoscanner method seems to be a good method, as confirmed by Mosór i Kromki-Szydek [6, 9] and Mikołajewska [10].

Mean values of each parameters in the presented study mostly fall within the norm which was used by authors. Only mean values of boys' Clark angle are slightly beyond the norm. Almost half of the examined feet reachedthe values of Clark angle which are an evidence of lower arch or flat feet. Transverse flat feet occurred in 15% cases, hallux valgus angle α beyond the norm was examined in 8% of feet. There was no statistically significant relationship between BMI and Clark angle or hallux valgus angle α. Normal values of Clark angle occurred more often in girls' feet. In the study group there was no statistically significant relationship between Wejsflog index,hallux valgus angle α and BMI. In the study group, lower values of Wejsflog index occurred in situations when BMI was higher. Thus, one might suppose that children with higher BMI more often had transverse flat feet.

In the examined study group of Klimczak et all [11], 48% of children had correctly formed feet, 25% of children had flat feet, 4% had higher arch. In that study there was no statistically significant relationship between different types of feet and age, sex and place of living. The majority of children had properly formed transverse arches. The authors highlighted that it is necessary to increase awareness of different feet problems and the prophylaxis thereof, and the authors of the presented study agree with that fact. In this study, the number of flat feet was lower.

Jankowicz-Szymańska and Pociecha [12] had similar observations to those found in this study connected to higher longitudinal arch of the study group of girls. Clark angle of boys increases with age - the girls had the highest values of that angle in the oldest group. The relationship between BMI and Clark angle was observed, which was not confirmed in the presented study.

Puszczałowska-Lizis et. all [13] while examining children attending thesecond class of primary school observed that the Clark angle is lower with weight, whereas the next conclusion showed that arches of feet among girls were formed in a better way.The study of Pauk et all [4], which involved 80 children aged 7-15, showed that problems caused by overweight can lead to problems in longitudinal arch formation, the highest intensity of formatting process of longitudinal arch falls at the age of adolescence. Longitudinal arch is higher in boys than girls, as boys tend to have flat feet. Also Puzder et all [14] observed that higher BMI influenced the occurrence of flat and valgus feet, and valgus knee. Disorders of feet occurred more frequently in girls' feet, and girls had more frequently transverse flat feet,. The most common case among boys' feet included longitudinal flat feet. However, Drzał-Grabiec [15] evaluated 239 children, aged 7-9, and observed that no correlation between longitudinal arch and weight existed, whichis similar to the presented study. Drzał-Grabiec [15] claimed that it is necessary to concentrate more on this topic, also authors of this study share a similar point of view.

As opposed to the previous studies, Woźnicka et all [16] claimed that nowadayslongitudinal arches are getting higher, however, in the previous study it was not observed.

The study of Sztandera et all [17] showed that hallux valgus occurred more frequently in girls' feet than boys'. The relationship between BMI and hallux valgus angle was not observed. Demarczuk-Wlodarczyk et all [18] observed that hallux valgus occurred more frequently in girls with overweight. Also in the study conducted by Bac [1] it turned out that girls had a tendency to develop hallux valgus, however, according to the research conducted by Kędra [19] disorder of hallux valgus was examined more often among boys. In the previous study there was no relationship between sex, BMI and hallux valgus angle α.

Conclusion

1. In study group there is no statistically significant relationship between BMI and Clark angle.
2. The girls in the study group more frequently had normal values of Clark angle. Wejsflog index is slightly higher in girls' feet.
3. Children with higher BMI have lower values of Wejsflog index, which is an evidence of lower longitudinal and transverse arch.
4. In the study group there was no statistically significant relationship between BMI, sex and hallux valgus angle α.

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