

EVALUATION OF THE FOOT ARCH SHAPE AND TOES DEFORMITIES AMONG UNIVERSITY STUDENTS

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Abstract: *Pes planus* ("flat feet") is one of the most common orthopaedic conditions observed in adult health practice. The purpose of this study was to evaluate the foot arch quality and the occurrence of toes deformities among physiotherapy students ($N = 106$; 33 men and 73 women). The mean age of students was 22.28 years. The CQ-ST Podoscope was used as the main research tool. We evaluated the Clark's angle and Weisflog index as foot parameters to assess the quality of the longitudinal foot arch and the transverse foot arch, respectively. We also evaluated the incidence of toes deformities of the big toe angle (ALFA) and little toe angle (BETA) according to Weisflog. Most students had a physiologically arched longitudinal foot arch. Despite the young age of subjects, we found an increased occurrence of the flat transverse foot arch and big toe deformities, especially among women.

Key words: *Students. Clark's angle, Weisflog index, Foot arches, Flat feet.*

1. Introduction

The development of the human foot took many millions of years, during which it underwent a number of changes. Thanks to civilization stimuli, the human foot is still evolving. The thumb toe was originally separated from the toes, but gradually lost grasping ability and merged with the other fingers, which subsequently shortened. The heel widened and grew larger. These shape changes are the result of the abandonment of tree life, which was

caused by movement on the solid ground and at the same time by a change in the way of movement [16]. At the level of functional anatomy, the human foot fulfils two important functions, ensuring the standing position and human locomotion. The foot thus fulfils the static function by carrying the weight of the whole body (allows standing and upright posture) and dynamic function by allowing human locomotion, reducing impacts on the surface during walking and adapting to the shape of the ground) [14]. Therefore, the

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foot must be sufficiently flexible and rigid enough. When walking, each step must begin with a foot as a flexible and adaptable structure and end with a rigid lever. There are dozens of joints between the bones. From a functional point of view, the movement is considerably limited, but a certain elastic effect associated with minor displacements must be maintained for proper foot function [5], [6].

The arch of the foot refers to the less movable articulations of the ankle bones, the tarsal and metatarsal bones and the phalanges, which are strengthened by tendons, ligaments, foot and lower leg muscles [13]. There are three support points on the foot - the calcaneal tuberosity, the first and fifth metatarsal heads. The components thus together form the longitudinal and transverse arches of the foot, protecting the soft tissues of the foot and thus providing a flexible contact with the ground [7]. The foot arches are created by the active work of the toes and feet in the process of children's vertical movement and walking [12]. Almost every other adult walks through life with a foot disorder. The foot problems range from bruises and various fungal infections to various foot deformities, but also serious illnesses associated with insufficient blood flow, joint inflammation and arthrosis. Many of these diseases can be prevented [10]. The most common deformity is the flat foot. It is a broad term describing the lowered longitudinal arch of the foot with calcaneal valgosity. This descriptive term refers to an abnormally lowered longitudinal arch of the foot or even the loss of the arch. The integrity of the longitudinal and transverse arches is dependent on the configuration of the

bones, tarsal joints, and the tension among ligaments joining the particular bone structures of the foot. We must not forget about the muscle work [4], [9]. Pes planus or planovalgus is referred to as the static deformity in which the transition from physiological to pathological conditions is smooth. However, its occurrence is also associated with obesity and constitutional weakness of the ligaments. Pes planus may also occur after trauma, inflammation, bone metabolic diseases, shortening of the fibula as a result of rickets [24]. Pes cavus, or pes excavatus, refers to the elevated foot arch, which resembles a tense bow with a typical immovable middle part of the foot, high instep, and a small support surface. Pes transversoplanus refers to the lowered transverse foot arch, which is stretched and flattened. The occurrence of pressure sores on the soles of the feet, enlarged forefoot and the occurrence of toe deformities are typical signs of transverse arch problems [10], [11]. Relatively frequent toe deformities include hallux valgus (bunion), which is a complex defect caused by hereditary factors in combination with inappropriate, too pointed footwear that deviates the thumb from the axis, restricts muscle activity as well as overloading the forefoot [23]. Hallux valgus is often associated with the problem of a transverse flat foot, resulting from overloading the main joint of the thumb and the incorrect type of gait [19]. The interest of researchers in feet has contributed to the emergence of an independent science - podology that deals with the prevention and diagnosis, as well as the rehabilitation and treatment of foot defects. In this study, we determined the incidence of foot arch problems and hallux valgus and

bunionette of the little toe among university students.

2. Methods of Research

The study was conducted at the Department of Physical Therapy, Faculty of Healthcare, University of Presov, Presov, in 2019. The study was supported by the grant project VEGA 1/0376/19 entitled *Risk factors of university students' health in the context of physical activity*. The participants were full-time and part-time students of physical therapy at the Faculty of Health Care, University of Presov, Presov. The sample consisted of 106 students, 33 men (31.3%) and 73 women (68.7%). The mean age of students was 22.28 years. The primary research tool applied was the CQ-ST Podoscope. We evaluated the following foot parameters: Clarke's angle, which assesses the longitudinal foot arch. Clarke's angle was defined as the angle between the tangent at the medial margin of the footprint and the line connecting the longest perpendicular distance from the medial border of the foot and the point at which the medial tangent crosses the margin of the front foot. Clarke's angle in a normal foot ranges from 42° to 54° and in a flat foot it is up to 30°; low arch ranges from 31° to 41° and high arch starts from 55° [20], [25]. The transverse arch was assessed according to the Weisflog index. Values between 2.55 and 3.00 denote healthy transverse arch, and values between 2.00 and 2.50 denote transversely flat feet. Values over 3.00 indicate a high transverse foot arch [22]. ALFA angle – angle of hallux valgus. The angle of the hallux valgus should range

from 0° - 9°. Hallux valgus angles higher than 9° indicate hallux valgus deformity. We also evaluated the BETA angle, which is the angle of the fifth toe. The normal angle of the fifth toe ranges from 0° to 9° [25]. To determine correlations between gender and parameters indicating foot arch quality, we used the Pearson's correlation coefficient.

3. Results and Discussion

To assess the quality of the longitudinal foot arch (Table 1), we used the Clark's angle. Of 106 students, 75.5% and 78.3% of students had a physiologically healthy longitudinal arch on the right foot and left foot, respectively. A total of 13.2% and 11.3% of students were diagnosed with flat feet on the right foot and left foot, respectively. High arch on the right and left foot was diagnosed in 11.3% and 10.4% of students, respectively. The data above show low percentages of university students diagnosed with longitudinal foot arch disorders.

To assess the transverse foot arch (Table 2), we applied the Weisflog method. Compared with the longitudinal foot arch, lower number of university students had a physiologically healthy transverse foot arch. A total of 57.5% and 50.9% of students were diagnosed with a physiologically healthy transverse arch on the right and left foot, respectively. Flat transverse arch on the right foot and left foot was diagnosed in 42.5% and 49.1% of students. None of the students was diagnosed with a highly arched foot.

Quality of the longitudinal foot arch

Table 1

Foot arch characteristics	Right foot		Left foot	
	<i>n</i>	%	<i>n</i>	%
Physiologically healthy foot	80	75.5	83	78.3
Flat feet	14	13.2	12	11.3
Highly arched foot	12	11.3	11	10.4

Note. *n* - sample size

Quality of the transverse foot arch

Table 2

Foot arch characteristics	Right foot		Left foot	
	<i>n</i>	%	<i>n</i>	%
Physiologically healthy foot	61	57.5	54	50.9
Flat feet	45	42.5	52	49.1
Highly arched foot	0	0	0	0

Note. *n* - sample size

Table 3 shows the incidence of big toe and little toe deformities assessed using angle parameters according to Weisflog. Angles greater than 9° indicate a valgus position [21], showing a hallux valgus deformity of the big toe [25]. Of the entire sample of university students, 55.7% and 49.1% of students had a hallux valgus deformity on their right and left foot, respectively.

The incidence of the varus deformity of the fifth toe was lower. A total of 38.7% and 41.5% of students were diagnosed with a varus deformity of the fifth toe on their right and left foot, respectively.

The presented data show a bilateral incidence of toe deformities among almost half of the students.

Incidence of toe deformities

Table 3

Parameter	Characteristic	Right foot		Left foot	
		<i>n</i>	%	<i>n</i>	%
ALFA angle (<i>hallux valgus</i>)	normal	47	44.3	54	50.9
	pathological	59	55.7	52	49.1
BETA angle (<i>varus angle of the fifth toe</i>)	normal	65	61.3	62	58.5
	pathological	41	38.7	44	41.5

Note. *n* - sample size

Tables 4 and 5 present basic statistical characteristics of parameters observed among both men and women. There were no significant differences in mean values between men and women. The only significant correlation ($p = 0.020$) was found between the hallux valgus

deformity and gender (Table 6).

As reported by other authors, women were diagnosed with a larger number of hallux valgus deformities than men. As reported by other authors, women were diagnosed with a larger number of hallux valgus deformities than men.

Descriptive characteristics of foot parameters: women ($n = 73$) Table 4

Parameters - Women	Right foot		Left foot	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Clarke's angle	49.00	6.39	49.85	4.71
Weisflog angle	2.73	0.32	2.91	0.22
ALFA angle	4.32	3.83	5.52	5.02
BETA angle	19.67	5.89	19.61	4.91

Note. *M* - arithmetic mean; *SD* - standard deviation

Descriptive characteristics of foot parameters: men ($n = 33$) Table 5

Parameters - Men	Right foot		Left foot	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Clarke's angle	48.26	9.67	48.73	5.87
Weisflog angle	2.82	0.22	2.91	0.28
ALFA angle	3.39	4.21	2.52	4.07

Note. *M* - arithmetic mean; *SD* - standard deviation

Correlation between gender and foot parameters Table 6

Parameters	Left foot		Right foot	
	<i>r</i>	<i>p</i>	<i>r</i>	<i>p</i>
Clarke's angle	-0.061	0.605	-0.058	0.619
Weisflog angle	0.690	0.558	0.117	0.317
ALFA angle	0.268	0.020	0.268	0.020
BETA angle	-0.206	0.077	-0.206	0.077

Note. *r* - correlation coefficient; *p* - p-value

According to the results of the study, the incidence of either flat foot or highly arched foot among university students was minimal. Similar findings were reported by [18] for a sample of 208 students. [2] conducted a cross-sectional study to determine the incidence of highly arched or flat feet among the sample of 150 students using the navicular drop test and podoscopic examination. The results of this study showed that 36.6% were diagnosed with pes planus and 16.6% of students with pes cavus. [3] found a bilateral incidence of flat feet among 11.25% of physical therapy students. Despite the fact that other studies show a

low incidence of flat transverse foot arch among university students, our results have confirmed a bilateral incidence of flat transverse foot arch among half of the male and female students of physical therapy. [23] carried out a study to assess foot health condition using plantograms among 170 students of the Comenius University in Bratislava. The participants were 80 men and 90 women whose mean age was 21.4 years. The purpose of the study was to analyse foot arches using the Chippaux-Smirak index and toe deformities using the angles of big and little toes according to the Weisflog method. The results of this study show

that relatively young adults suffer from various foot deformities, which is consistent with our findings. A similar study was conducted by [8] who assessed the quality of the longitudinal foot arch, ankle joint range of motion and hallux valgus deformities among 163 medical faculty students, 74 females and 89 males. The differences between males and females in terms of the ankle range of motion ($p < .000$) and incidence of the hallux valgus ($p < .043$) were statistically significant. Differences between males and females in the foot structure have been confirmed in numerous published studies [8] [15]. Gender is to be considered a risk factor determining the origination of toes deformities.

Using the analysis of correlation between body mass index (BMI) and Weisflog angle, multiple authors point to the statistically significant effect of obesity on the transverse foot arch. The Weisflog index decreased with increasing BMI [1] [18]. [17] determined the effect of the foot arch quality and toes deformities among students. On the basis of the analysis of body mass influence on individual indicators characterizing foot structure, the research proved that indicators exceed the norms in case of obese students in comparison to students with correct body mass.

4. Conclusion

The university students who participated in this study were predominantly diagnosed with physiologically healthy foot arch. Despite the fact that the subjects were young adults, almost half of the students were diagnosed with flat transverse foot arch. More than a third of university students

had a valgus deformity of the fifth toe. Hallux valgus was diagnosed in half of the students, especially women. We assume that these foot deformities are caused by wearing inappropriate footwear.

References

1. Adamczyk, M., Gawrpńska, K. et Lorkowski, J.: *Ocena budowy anatomicznej stóp u studentów Uniwersytetu Kochanowskiego w Kielcach (Anatomy of the feet in students of the Kochanowski University v Kielcach)*. Ostry dyżur, Vol. 9, No. 3, 2016.
2. Ashraf, T. et al.: *Prevalence of Flat Foot and High Arch Foot among undergraduate Physical Therapy students by using Navicular Drop Test*. International Journal of Advancements in Research & Technology. Vol. 6, No. 10, 2017, p. 21-28.
3. Boir, T. et al.: *Prevalence of flat foot among 18 -25 years old physiotherapy students: cross sectional study*. Indian Journal of Basic and Applied Medical Research. Vol.3, No. 4, 2014, p. 272-278.
4. Dungal, P. et al.: *Ortopedie (Orthopedics)*. 2. vyd. Praha. Grada Publishing, 2014.
5. Dylevský, I.: *Funkční anatomie (Functional anatomy)*. 1. vyd. Praha. Grada Publishing, 2009.
6. Dylevský, I.: *Speciální kineziologie (Special kinesiology)*. 1. vyd. Praha. Grada Publishing, 2009.
7. Dylevský, I., Kubálková, L., Navrátil, L.: *Kineziologie, kinezioterapie a fyzioterapie (Kinesiology, kinesiotherapy and physiotherapy)*. 1. vyd. Praha. Manus, 2001.
8. Erden, A. et al.: *Impact of body mass*

- index and gender on medial longitudinal arch drop in young healthy population. Medicina Sportiva, Vol. IX, No. 2, 2013, pp. 2076-2082.*
9. Kolář, P. et al.: *Rehabilitace v klinické praxi (Rehabilitation in clinical practice)*. 1. vyd. Praha. Galén, 2009.
 10. Larsen, Ch.: *Zdravá chůze po celý život (Healthy walking throughout your life)*. Olomouc. Poznání, 2005.
 11. Larsen, Ch., Miescher, B., Wickikalter, G.: *Zdravé nohy pro vaše dítě (Healthy feet for your child)*. 1. vyd. Olomouc. Poznání, 2008.
 12. Lewitová, C. M. H.: *O dětských nohách (About children's feet)*. In: *Umění fyzioterapie*, No. 1, pp. 5-7, 2015.
 13. Merkunová, A. and Orel, M.: *Anatomie a fyziologie člověka pro humanitní obory (Anatomy and Physiology for Humanities studies)*. 1. vyd. Praha. Grada, 2008.
 14. Novotná, H.: *Děti s diagnózou plochá noha ve školní a mimoškolní TV, ZTV a v mateřských školách (Children diagnosed with flat foot in school and after-school physical education, health physical education and kindergarten)*. Praha. Olympia, 2001.
 15. Paiva de Castro, A. et al.: *The Effect of Gender on Foot Anthropometrics in Older People*. *Journal of Sport Rehabilitation*, Vol. 20, No.3, 2011, pp. 277-286.
 16. Popelka, S. et al.: *Chirurgie nohy a hlezna (Surgery of the foot and ankle)*. 1. vyd. Praha. Mladá fronta a. s., 2014.
 17. Przsada, G., Družbicki, M., Łyszczak, N.: *Wpływ masy ciała na powstawanie wad stóp u studentów piątego roku fizjoterapii Uniwersytetu Rzeszowskiego (The Influence of Body Mass on the Formation of Foot Defects at Fifth Year of Physiotherapy students of Rzeszow University)*. *Przegląd Medyczny Uniwersytetu Rzeszowskiego i Narodowego Instytutu Leków w Warszawie*, No. 3, 2013, pp. 319-326.
 18. Puszczalowska-Lizis, E., Kwolek, A.: *Częstość występowania płaskostopia podłużnego u młodzieży akademickiej w świetle różnych technik opracowania plantogramu (Frequency of occurrence of longitudinal flat feet in students in the light of different techniques of plantography preparations)*. *Przegląd Medyczny Uniwersytetu Rzeszowskiego i Narodowego Instytutu Leków w Warszawie*, No. 3, 2011, pp. 305-314.
 19. Riegerová, J., Přidalová, M.: *Morfologie nohy a její hodnocení (Foot morphology and its evaluation)*. In: Riegerová, J., Přidalová, M., Ulbrichová, M. (ed.): *Aplikace fyzické antropologie v tělesné výchově a sportu (příručka funkční antropologie) (Application of physical anthropology in physical education and sport (manual of functional anthropology))*. Olomouc, Nakladatelství HANEX, 2006, pp. 163-181.
 20. Riegerová, J., Přidalová, M., Ulbrichová, M.: *Aplikace fyzické antropologie v tělesné výchově a sportu: (příručka funkční antropologie) (Application of physical anthropology in physical education and sport (manual of functional anthropology))*. 3. vyd. Olomouc. Hanex, 2006.
 21. Riegerová, J., Žeravová, M., Peštuková, M.: *A contribution to the foot morphology of school children and teenagers between the ages 12-18 in Moravia*. *Slov. Antropol.*, Vol. 6, No.1, 2003, pp. 112-117.
 22. Rykała, J. et al.: *Ocena wysklepienia podłużnego i poprzecznego stóp w*

- warunkach odciążenia i obciążenia masą własną u dzieci w wieku 7–10 lat (Evaluation parameters of longitudinal and transverse arches of the feet in both non-weight bearing and weight-bearing conditions in children aged from 7 to 10). Przegląd Medyczny Uniwersytetu Rzeszowskiego i Narodowego Instytutu Leków w Warszawie, Vol. 11, No. 2, 2013, pp. 183-193.*
23. Uhrová, P. et al.: *Vyhodnotenie zdravotného stavu nôh z plantogramov študentov UK v Bratislave (Evaluation of the health of legs with plantograms of students of Comenius University in Bratislava). Slovenská Antropológia. Vol. 19, No. 1, 2016, pp. 29-34.*
24. Vojtaššák, J.: *Ortopédia a traumatológia (Orthopedics and Traumatology)*. 1. vyd. Bratislava. SAP, 2006.
25. Wolan-Nieroda, A. et al.: *Assesment of Foot Shape in Children and Adolescents with Intellectual Disability: A Pilot Study*. Medical Science Monitor. Vol.11, No. 24, 2018. pp. 2149-2157.