THE RELATION BETWEEN WEIGHT PARAMETERS, GENDER AND FLAT FOOT IN PHYSIOTHERAPY STUDENTS

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Abstract:
Introduction: The foot is an important part of human body – it aids movement every day and it is the only part that maintains a direct connection with surfaces upon which the person is moving (Pfeiffer, 2006). **Objective:** The study focuses on flat foot and on the influence of body weight parameters on its prevalence. **Material and the methodology:** A total of 50 student subjects were examined. The research assessed the quality of the arch of the foot as well as analysed the impact of selected factors on the prevalence of the flat foot. The quality was assessed using a diagnostic device - plantoskop and a visual scale according to Kapandji. Data on BMI and on body fat percentage were determined by means of basic anthropometric measurements. Selected parameters are stated as an arithmetic mean plus standard deviation. Correlations between the parameters were analysed using Pearson's chi-squared test. **Results:** The research results suggest a higher prevalence of flat foot in males. Overweight and obesity were detected only in a small proportion of the sample. The body fat percentage in females was mostly low: in the border health minimum category. Results showed significant correlations between the prevalence of flat foot on the right side according to Kapandji and female gender. **Conclusion:** The results do not confirm the influence of body weight parameters on the prevalence of flat foot.

INTRODUCTION

The foot is an important part of human body – it aids movement every day and it is the only part that maintains a direct connection with surfaces upon which the person is moving. One third of flat foot causes result from genetics. Two thirds are external, such as unsuitable shoes, overloading or bodyweight. Overweight and spreading obesity epidemics, insufficient movement and an unhealthy lifestyle are the preconditions for the development of deformities in the arch of the foot and the subsequent functional and later also structural disorders of the musculoskeletal apparatus. Provided the more consistent focus on the foot in general, its disorders and their treatment, successful treatment of dysfunctions stemming from the foot and influencing knee, pelvis and spine, is possible (Pfeiffer, 2006; Riegerová, 2006; Heiner, 2004; Svačina - Bretšteindrová, 2008).

The skeleton of a growing child suffering from obesity is markedly burdened and disorders frequently occur (Pařízková, 2007). The lower limb skeleton is significantly burdened and coxa vara, genua valga and flat foot occur. Excessive body weight burdens the joints of the lower limb and arthritic changes occur in the long term. An obese child stands poised on a broad basis (Pastucha, 2011). Pastucha (2011) claims that it is a change in the basic posturing of a child that causes the valgus position of the knee joints and their recurvation along with the subsequent valgus position of ankle joints and lowering of the transverse and longitudinal arch of the foot. Hlaváček (2005) confirms these claims through the experiment conducted in the Czech Republic in 2005. The footprints of a sample of 110 obese children aged 10–18 years, placed in weight reduction camp, were collected and assessed at the beginning and end of a three-week stay. The experiment confirmed that child obesity (especially in cases with higher BMI) significantly increases the ratio of feet loading. However, after weight reduction, the feet can renew their functional parameters. Pffeifer (2006) states that significant differences in flat foot prevalence were observed in children who were overweight, obese and of normal weight. His study aimed to establish the prevalence of the flat foot in a population of 3- to 6-year-old children to evaluate cofactors such as age, weight, and gender. 835 children took part in the research. A significantly higher tendency toward flat foot was observed in boys. Prevalence in boys was 52% and in girls 36%, while 13% of the children were overweight or obese. Obesity influences the overall posture of an individual, including the foot. A dysfunctional foot is the cause of a grave disruption in movement patterns and therefore causes problems in the pelvis, lumbar and even cervical spine. The dysfunctional arch of the foot results in distorted afferentation. After stimulation a change in the pelvic posture occurs alongside the direct activation of the deeper layers of the pelvic floor (Buchtelová, 2010).

Flat foot (pes planus) is a descriptive term denoting a significant lowering or even a disappearance of the longitudinal arch of the foot (Adamec, 2005). Paediatric flat foot and adult acquired flat foot are described. The term paediatric flat foot (pes planovalgus) denotes a deformity of the foot occurring during growth and involving the flattening of inner longitudinal arch. The heel is in a heightened valgus (outwards turned) position (Benczová, 2010). Paediatric flat foot often occur in children younger than 3 years. It is considered a normal occurrence at this age (O´Callaghan, 2005). The etiology is unknown. Causes include the reduced strength of the ligament or joint sheaths, mechanical factors related to obesity or wearing improper shoes. Some authors, however, consider flexible paediatric flat foot the result of upright standing and walking. Flexible flat foot is asymptomatic. The clinical diagnostic criteria for paediatric flat foot include the lack of the medial tilting of the foot at age 6 or more years and the valgus position of the heel by more than 20° (Gallo, 2011). Adult acquired flat foot is a static deformity, which can occur at any age after the completion of bone growth due to various factors, especially long-term overloading. A part of paediatric flat foot cases can transfer to adulthood. Adult flat foot can develop also on an originally physiological foot. Such deformity develops as a result of a load chronically disproportionate to the load-bearing capacity of the foot. Its development, however, is also related to the anatomical and functional failure of the m. tibialis posterior sinew and the calcaneonavicular ligament plays an important role, too. It occurs quite often and affects mainly women aged 40–60 years (Gallo, 2011; Dungl 2005; Vojtaššák 2006; Hudec 2004).

Flat foot stages (Hošková, 2012; Riegerová, 2006):

Stage 1 or “tired foot”: the shape of the foot is retained and the problem occurs only under load while standing and walking; the ligaments are firm, but the function of the fixating joints is impaired; the examination usually finds the valgus position of the heel.

Stage 2 or “flaccid foot”: problems occur at rest and under load; the ligaments are loose; swelling and fatigue are present; the arch of the foot is lowered under load and after unloading it returns to the correct position.

Stage 3: the arch of the foot remains flattened; however, it is loose and can be passively formed back to a normal state.

Stage 4 or “stiff flat foot”: it cannot be passively formed into normal shape, it hurts, the heel valgus; the forefoot passes into pronation with the extension of the medial column and extends; the thumb is pushed into a valgus position; the elevation of the border metatarsals is present, which causes plantar calluses; hammer toes develop; inflexible walking leads to pain in the shins, knees, hip joints and lumbar spine.

The development of static flat foot occurs due to a load disproportionate to the load-bearing capacity of the foot. In terms of cultural influences, a long-term work-related load, lack of exercise and rest, overweight and obesity are important. Genetic predispositions represent a third of the causes and the way we approach and treat feet represents two thirds. The latter mostly includes inappropriate loading and lack of exercise (Riegerová, 2006; Larsen 2005). Given this information, we have decided to conduct a research into the quality of the arch of the foot in physiotherapy students, as their future work places a lot of load, both static and dynamic, on the feet.

MATERIAL AND THE METHODOLOGY

The aim of the study was to assess the quality of the leg curve as well as to analyse the influence of BMI on prevalence of the flat foot and also the gender influences the prevalence of flat foot.

The research was conducted as a pilot study on a sample of students from the Faculty of Health Care of Prešov University in October and November 2016. The sample included a total of 50 students, 31 of them women and 19 men. The average age of a student was 21.4 years (SD±2.92). Students were selected by random selection. The research was conducted at the Department of Physiotherapy at the Faculty of Health Care, University of Prešov. Research was approved by the Ethics Committee of the University of Prešov in Prešov. Participating students were informed about the course of the study and signed informed consent. We conducted the investigation as part of the Kega project no. 044PU -4/2016 "Innovation of Health-Oriented Educational Resources for Future Physical and Sports Teachers and Sports and Health Professionals". Observed parameters were collected by a research protocol. The protocol was anonymous and focused on age, gender and somatometric parameters. Somatometric measurements were used to assess body height and weight. The BMI index was determined. Body fat percentage was determined using the Pařížková (2011) caliperation method. The morphological shape of the foot was determined using the visual assessment scale according to Kučera (1994).

The quality of the arch of the foot was assessed using the plantoskop diagnostic device. A participant stood on the mirror with the whole area of the foot and the shape of the arch of the foot was observed. The shape was assessed using the visual assessment scale according to Kapandji (Riegerová, 2006).

The visual scale according to Kapandji includes the four stages of foot assessment: a healthy foot – the arch of the foot corresponds to a healthy foot criteria; Stage 1 of flat foot – moderate flat foot; Stage 2 of flat foot –painful flat foot; Stage 3 of flat foot – the arch of the foot is significantly lowered even after removing the load.

Collected data was used to calculate the ratios of changes to the arch of the foot as well as other somatometric and socio-demographic characteristics against the whole sample. Selected parameters are stated as an arithmetic mean plus standard deviation. Correlations between the parameters assessing the quality of the arch of the foot and the observed factors

were analysed using Pearson's chi-squared test. The significance level of $p<0.05$ was considered significant in all calculations, with a confidence interval of 95%. STATGRAPICS Centurion XV statistical software was used to calculate the frequency data and analyse variance. MS EXCEL XP and SPSS 15 for Windows were used for descriptive statistics.

RESULTS

Table 1 presents the quality of the arch of the foot and the percentage of prevalence of flat foot, healthy foot and high foot in men and women – assessed using the method according to Kapandji (Riegerová, 2006). Out of the 19 men, right flat foot occurred in 11 (57.9%) and left flat foot occurred in 7 (36.8%). Stage 1 flat foot occurred in 9 (47.4%) on the right side and in 7 (36.8%) on the left side. Stage 2 flat foot occurred on the right side and only in 2 (10.5%) men. There were none on the left side. Stage 3 flat foot was not identified in men. As for the sample of 31 women, right flat foot were identified in 6 (19.3%) cases and left in 9 (29.0%) cases. Stage 1 flat foot occurred in 5 (16.1%) women on the right side and in 8 (25.8%) on the left side. Stage 2 flat foot occurred on the right side and only in 1 (3.2%) woman. No left flat foot was identified. Stage 3 flat foot occurred on the left side and only in 1 (3.2%) woman. No Stage 3 right flat foot was identified. A total of 17 (34%) cases of flat foot on the right side and of 16 (32%) cases of flat foot on the left side were identified, using the method according to Kapandji (Riegerová, 2006).

Table 1 *Prevalence of disorders in the quality of the arch of the foot according to Kapandji, by gender*

	Healthy foot		**Flat foot**		**High foot**	
	Right n %	Left n %	Right n %	Left n %	Right n %	Left n %
Men (n=19)	5 26.3%	8 42.1%	**Stage 1** 9 47.4%	**Stage 1** 7 36.8%	3 15.8%	4 21.1%
			Stage 2 2 10.5%	**Stage 2** 0 0%		
			Stage 3 0 0%	**Stage 3** 0 0%		
			Total 11 57.9%	**Total** 7 36.8%		
Women (n=31)	21 67.7%	17 54.8%	**Stage 1** 5 16.1%	**Stage 1** 8 25.8%	4 12.9%	5 16.1%
			Stage 2 1 3.2%	**Stage 2** 0 0%		
			Stage 3 0 0%	**Stage 3** 1 3.2%		
			Total 6 19.3%	**Total** 9 29.0%		
Total (n=50)	26 52%	25 48%	17 34%	16 32%	7 14%	9 18%

1 - tired foot; 2 - flaccid foot; 3- the arch of the foot remains flattened; 4- stiff flat foot

Table 2 presents the average BMI in men was 27.67% and in women 20.26%. This corresponds, according to the WHO criteria, to first degree obesity in men and normal body weight in women. The average fat percentage in men was 16.5%, i.e. the medium fat percentage category according to the standards for fat percentage in men and women (Heyward, 2004). The average fat percentage in women was 20.36%, corresponding to the low-fat percentage or below-average fat percentage category.

Table 2 *Average values and standard deviations of identified body weight parameters*

Gender	Average BMI	Average fat percentage
men	27.67 kg/m^2 SD±9.59 min. 16.8; max. 38.42	(16.5%); SD±7.46 min. 7.9; max. 25
women	20.26 kg/^{m2}; SD±3.63, min. 17.42; max. 36.73	20.36%; SD±12,89 min. 16.4; max. 32.95

Table 3 shows the correlation between the prevalence of flat foot and the BMI of test subjects. Based on the correlation, we have found that there is no statistically significant relation between the two parameters. The prevalence of flat foot in our sample did not depend on the BMI. Table 3 also states the correlation between the prevalence of flat foot on the right side according to Kapandji (Riegerová, 2006) and female gender; it was statistically significant at the level of significance of p=0.05. Female gender significantly influences the prevalence of flat foot. The correlation between the prevalence of flat foot on the left side and female gender was statistically not significant.

Table 3 *Correlation of flat foot prevalence average, BMI and female gender assessed by Pearson's correlation*

		BMI	FEMALE GENDER
FLAT FOOT ACCORDING TO KAPANJI (RIGHT SIDE)	r	-0.112	-0.360*
	p	0.439	0.010
	n	50.00	50.00
FLAT FOOT ACCORDING TO KAPANDJI (LEFT SIDE)	r	-0.095	-0.031
	p	0.511	0.831
	n	50.00	50.00

*Correlation is significant p<0.05

DISCUSSION

Tejashree Bhoir (2014) conducted a similar study in India on a sample of 80 physiotherapy students aged 18–25. She identified the prevalence of flat foot on both sides in 11.25% of the students. Cetin's (2011) study conducted on 622 children aged 6–13 in Anatolia states the prevalence of flat foot in girls to be 35.5% and in boys 28.5%. Hreško's (2009) research of 100 athletes aged 18–28 used the Striter-Godunov method of flat foot assessment by plantogram. 37% showed Stage 1 flat foot, 12% showed Stage 2 flat foot and 7% Stage 3 flat foot. Fuchsová (2013) conducted a research on a sample of 57 female students from the Faculty of Education, Comenius University. Plantograms were assessed according to the Chipaux-Šmířák method. Stage 1 flat foot was present on the right side in 3.51% and on the left side in 7.02%. Stage 2 was present on the right side in 1.75% and on the left side in 3.51%. Stage 3 was not identified.

The average BMI in Fuchsová's (2013) research of 57 female students from the Faculty of Education, Comenius University aged (average) 21.3 was similar to our sample. The average value in the first-degree obesity category was 31.01 kg/m^2. Bézayová (2015) claims, that according to the MONIKA project implemented in Slovakia in 2002, on a sample of 6,876 subjects aged 15–64, 35% women are obese in the first degree. Men amounted to 48%.

However, Butterworth (2015) conducted an experiment with 68 respondents of 52 years in average and claimed a positive correlation between body weight and the height of the transverse and longitudinal arches of the foot. Also, Shibuya's (2010) study from the US found a statistically significant influence of the BMI on the prevalence of the flat foot in adults.

After the evaluation of our results we can state that they do not correspond to those of Milenkovic (2011). His research conducted on 228 teenagers did not identify any significant

difference in the prevalence of flat foot given the gender. However, Chang et al. (2010) state a statistically significant influence of male gender on the prevalence of flat foot in 1,222 Taiwanese school children. On the other hand, Eluwa et al. (2008) state a statistically significant influence of female gender on the prevalence of flat foot in the sample of 1,000 students aged 20–30 in the Akwa Iborn state of southern Nigeria. Heba Hazzaa H. et al. (2015) came to the conclusion, that the prevalence of flat foot is influenced by gender. Their results confirmed a significant correlation between gender and the prevalence of flat foot in obese children. Higher prevalence was observed in obese men as compared with women.

CONCLUSION

Worldwide studies confirm that overweight and obesity cause an increase in deformities of the foot of the arch in a given population. Our research, however, did not confirm the tendency. The results, however, are still important, especially given the nature of our sample, i.e. active students. Based on the overall assessment of the quality of the arch of the foot in the Department of Physiotherapy at the Faculty of Health Care, University of Prešov students, we can conclude that deformities affect only a minimal part of the sample, which correlates to similar research conducted in Western countries on samples of students of study branches focusing on movement. The results confirmed a significant correlation between gender and the prevalence of flat foot in students.

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