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Original empirical article

INCIDENCE OF FLAT FOOT IN HIGH SCHOOL STUDENTS*

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Abstract. *Introduction: Flat foot in children and adolescents, as a consequence of various factors such as hypo kinesis, overweight or hereditary factors, represents a current problem. Aims: The main aim of actual research was to determine the incidence of flat foot in secondary school students. Methods: The sample of subjects consisted of 228 high school students, males and females whose body height was 173,65±9,10 in cm, weight 63,99±11,18 in kg, age 16,64±0,88 years (Mean±St.Dev.). The data for the current research were gathered as part of the scientific project no 179024, financed by the Ministry of Science and Technological Development of the Republic of Serbia (RS). By using a modern computerized podoscope "Pedic" (Hungary) with associated software, the following variables of the foot were determined: 1) PesNoL; 2) PesNoR (normal left foot and right foot, respectively) expressed numerically by 0; 3) PesPlL; 4) PesPlR (degree of the deformity of the left foot and right foot, respectively) expressed numerically by 1, 2, 3 or 4. In order to process the data, the package "SPSS version 13" was used, and the given results were presented descriptively, and by the z-test for the differences between two proportions. Results: By careful foot print*

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examination of totally 228 subjects, the presence of flat foot (feet) was determined in 111 subjects (48,7%), vs. 117 subjects (51,3%) with normal feet i.e., no deformity. By the usage of z-test for the differences between two proportions, it was checked whether the percentage of subjects with normal feet was significantly higher than the percentage of subjects with any degree of deformity. Significance of the z-test (sig=0,523), showed there was no significant difference in percentage of subjects with normal and flat feet. Conclusion: The results of the actual research regarding the incidence in flat feet could be described as very unsatisfactory. Causes of high incidence could be various: obesity, genu valgum, femoral and tibial torsional abnormalities, ligament laxity, footwear influence, and as like. Determined problem, physiological flat feet can be reconstituted by certain exercises (e.g. by extension of the great toe or by standing on the tiptoes).

Key words: *Flat foot, high school students, incidence.*

INTRODUCTION

Flat foot in children and adolescents, as a consequence of various factors such as hypo kinesis, obesity or hereditary factors, represents a current problem. It may be classified as physiological or pathological (Staheli, 1987). Physiological flat foot is a normal variation; it causes no disability (Chen et al., 2003) and tends to improve with time, while pathological flat foot is often characterized by stiffness of the foot, causes disability, and requires treatment (Staheli, 1999). According to Sullivan (1999), in cases of pediatric flat foot, the easiest way to prevent and even correct flat foot is going barefoot as often as possible, and especially over terrain such as the beach where muscles are given a good workout, while in most cases no treatment is necessary (Luhmann, 2000; Sullivan, 1999). On the other hand, Connors (1998) suggested treatment as a prevention of joint damage, and the later appearance of rigid foot deformity. The ideal foot, covered in a variety of medical textbooks, rarely exists in practice. So, physical activity is increasingly recognized as an important component of primary prevention of the disease. On the other hand, most injuries in adolescent athletes occur due to excessive physical activity, rather than sudden traumatic events. Adolescent athletes as well as adults have a tendency towards bad form, bad habits and improper implementation of the training process. The anatomical shape of the rear, middle and front of the foot may predispose athletes to specific injuries (Kennedy et al., 2005). Gross et al., 2000 suggested that postural changes may lead to increased risk of injuries, once postural malalignment causes an extra overload and demands more effort from the joint; there is an improper biomechanical action of the joint, creating unnecessary stress on, and stretching the soft tissues of the subject, decreasing muscular and ligamental efficiency that maintains the balance of the joint. Lifield (1994) pointed out that there is a correlation between the occurrence in injuries and foot form and function, and the resulting injury may lead to the cessation of sport activities in athletes (Razeghi and Batt, 2000). Echarri and Forriol (2003) found a greater incidence of flat feet among children from urban areas when compared to children from rural areas. Esterman and Pilotto (2005); Rao and Joseph (1992) pointed out that flat foot is most common in children who wear closed-toe shoes, less common in those who wear sandals or slippers, and least common in the unshod. Throughout the history of human evolution, runners were either barefoot or shod in for instance, light moccasins, and a running step included pushing off the ground with the front and middle part of the foot, unlike today's runners, who push off the ground with the back of the foot, aided by an elevated heel and

soft modern running shoes (Lieberman et al., 2010). The aim of this research was to determine the incidence of flat foot in secondary school students and evaluate the relationship between flat foot and gender, and athletes and non-athletes.

METHODS

The sample of subjects consisted of 228 high school students, males and females whose body height was 173,65±9,10 cm, weight 63,99±11,18 kg, age 16,64±0,88 years (Mean±St.Dev.). The sample was divided into two sub-samples. The subjects of the first sub-sample (N=108) were actively engaged in different sport activities, while the subjects of the second sub-sample (N=120) were non-athletes. All of the subjects were familiar with the tasks and gave their written consent for their participation in the research, conducted in accordance with the Helsinki Declaration, at the Faculty of Sport and Physical Education in Niš. The data for this research were gathered as part of scientific project no. 179024, supported by the Ministry of Science and Technological Development of the Republic of Serbia (RS). By using a modern computerized podoscope "Pedic" (Hungary) along with the necessary software, the following variables of the foot were determined: 1) PesNoL; 2) PesNoR (normal left foot and right foot, respectively) expressed numerically as 0; 3) PesPlL; 4) PesPlR (degree of the deformity of the left foot and right foot, respectively) expressed numerically as 1, 2, 3 or 4. The numbers 1, 2, 3 and 4 indicate a greater degree of deformity (respectively). While the status of their feet was being determined, the barefoot subjects took up a standing position on a glass platform of the podoscope. A mobile camera located under the glass platform of the podoscope recorded the subject's feet in just a few seconds. In relation to the strength of the foot pressure on the glass, an isochromatic map was obtained. The degree of deformity was computationally determined based on the four physiological support points of the foot. In order to process the data, the package “SPSS version 13” was used, and the given results were presented descriptively, along with the results of the z-test for the differences between two proportions (Pallant, 2007).

RESULTS WITH DISCUSSION

By the careful examination of the foot prints of 228 subjects, the presence of flat foot (feet) was determined in 111 subjects (48.7%), vs. 117 subjects (51.3%) with normal feet i.e., no deformity. The significance of the z-test used in order to check whether the percentage of subjects with normal feet was significantly higher than the percentage of subjects with any degree of deformity, showed there was no significant difference in the percentage of subjects with normal and flat feet (sig=0.52). The results on the incidence of foot deformity in this research are in agreement with the results of the research carried out by Krsmanović et al. (2010), who reported a flat foot incidence of 44% in their general check-up of 200 female students in Serbia, aged 20 (±6 months). At the same time they indicate a lower incidence in comparison to the results of the research carried out by Bogdanović et al. (2009), who determined a flat foot incidence of 69.11%, from a total number of 651 primary school students of both sexes, aged between 7 and15. In relation to their engagement in sport activities, out of 108 athletes, the presence of flat foot (feet) was determined in 55 subjects (50.9%), vs. 53 subjects (49.1%) with normal feet i.e., no

deformity. In the case of the non-athletes, of the 120 subjects, the presence of flat foot (feet) was determined in 56 subjects (46.7%), vs. 64 subjects (53.3%) with normal feet i.e., no deformity. The significance of the z-test used to check whether the percentage of athletes with normal feet was significantly higher than the percentage of non-athletes with normal feet, showed there was no significant difference in two mentioned percentages (sig=0.527). Michelson et al. (2003) carried out a study which included a total of 196 subjects i.e., 83 athletes engaged in contact sports. They suggested that the existence of flat footedness does not predispose athletes to subsequent lower extremity injury and that routine prophylactic use of orthotics in flat-footed athletes to prevent future injury may not be justified. Yeung, S.S. et al. (2011), in their research which included 30252 subjects, did not find any evidence to support the use of shoe insoles for the reduction of other lower limb soft-tissue injuries, or evidence to support the claim that running shoes prescribed to suit individual foot shape are better than standard running shoes for preventing injuries in military recruits.

Table 1. Descriptive statistics of incidence in foot deformity among athletes (N=108) and non-athletes (N=120) and the z-test for the differences between two proportions.

Degree of foot deformity	Athletes				Non-athletes			
	L		R		L		R	
	N	%	N	%	N	%	N	%
PesNo(L or R)0	58	53,70%	72	66,67%[b]	76	63,33%[b]	75	62,50%
PesPl(L or R)1	0	0,00%	0	0,00%	0	0,00%	0	0,00%
PesPl(L or R)2	50	46,30%[a]	36	33,33%[c]	44	36,67%[a]	43	35,83%[c]
PesPl(L or R)3	0	0,00%	0	0,00%[d]	0	0,00%	2	1,67%[d]
PesPl(L or R)4	0	0,00%	0	0,00%	0	0,00%	0	0,00%

[a]: p=0.03; [b]: p=0.18; [c]: p=0.90; [d]: p=0.18

The percentage of subjects with left foot deformity (PesPlL2) was significantly higher among athletes (sig=0.03). In the case of the right foot, based on the significance of the z-test for the differences between two proportions there is no significant difference in the percentage of subjects with a normal right foot (PesNoR0) between athletes and non-athletes (sig=0.18). The same conclusion was reached when the percentage of the second degree of the right foot deformity (PesPlR2) was compared (sig=0.90) and when the percentage of the third degree (PesPlR3) was compared (sig=0.18). No subject with a determined fallen arch (-es) complained of any disability. In relation to gender, of the 101 males, the presence of flat foot (feet) was determined in 55 subjects (54.5%), vs. 46 subjects (45.5%) with normal feet i.e., no deformity. In the case of the females, of the 127 subjects, the presence of flat foot (feet) was determined in 56 subjects (44.1%), vs. 71 subjects (55.9%) with normal feet i.e., no deformity. The significance of the z-test used to check whether the percentage of males with normal feet was significantly higher than the percentage of females with normal feet showed there was no significant difference in the two mentioned percentages (sig=0.120). In this research, the incidence of foot deformity in relation to gender is lower than the incidence determined by Chang et al. (2010), who reported a flat foot incidence of 67% for males and 49% for females in their general check-up of 1222 Taiwanese school children. On the other hand, the incidence rate in re-

lation to gender is higher than the incidence rate reported by Umar and Paul (2010), who determined a flat foot incidence of 13% in males and 12% in females out of 200 Yoruba school students, aged between 9 and 14. Eluwa et al. (2009) reported a flat foot incidence of 13.4% i.e., 5,8% in males and 6.2% in females, from the 1000 students of Akwa Iborn State of Southern Nigeria, aged 20-30. Didia et al. (1987) reported unilateral flat foot occurrence in 2,22% of the sample of subjects, and bilateral flat foot occurrence in 0,75% in the females and in 0,44% in the males, out of 990 school students (532 females and 458 males) aged 5-14. The authors suggested that early introduction to the use of shoes may lead to a predisposition for flat feet.

Table 2. Descriptive statistics of incidence in foot deformity among males (N=101) and females (N=127) and the z-test for the differences between two proportions.

Degree of foot deformity	Male				Female			
	L		R		L		R	
	N	%	N	%	N	%	N	%
PesNo(L or R)0	53	52,48%[a]	60	59,41%[c]	81	63,78%[a]	87	68,50%[c]
PesPl(L or R)1	0	0,00%	0	0,00%	0	0,00%	0	0,00%
PesPl(L or R)2	48	47,52%[b]	40	39,60%[d]	46	36,22%[b]	39	30,71%[d]
PesPl(L or R)3	0	0,00%	1	0,99%[e]	0	0,00%	1	0,79%[e]
PesPl(L or R)4	0	0,00%	0	0,00%	0	0,00%	0	0,00%

[a]: p= 0.09; [b]: p= 0.23; [c]: p= 0.45; [d]: p=0.38; [e]: p=0.37

In to the case of the left foot, based on the significance of the z-test for the differences between two proportions, there was no significant difference in the percentage of subjects with a normal left foot between males and females (sig=0.09). By comparing the percentage of subjects with a left foot deformity of the second degree (PesPlL2) between males and females, no significant difference was determined (sig=0.23). Based on the significance of the z-test for the differences between two proportions, no significant difference was determined in the percentage of subjects with a normal right foot between the males and females (sig=0.45). The same conclusion was reached when the percentage of the second degree of the right foot deformity was compared (PesPlR2: sig=0.38) and when the percentage of the third degree was compared (PesPlR3: sig=0.37). Concerning other studies related to feet status and sport achievement, Tudor et al. (2009) found no relation between the degree of fallen arches and several motor skills that are necessary for sport performance (eccentric-concentric contraction and hopping on a Kistler force platform, speed-coordination polygon-Newtest system, 3 balance tests, toe flexion i.e. textile crunching, tiptoe standing angle, and repetitive leg movements) in the research which included 218 children aged 11-15. On the other hand, Živković, M. et al. (2012) found that participants with normal (healthy) feet were more successful in the applied motor tests for determining explosive strength i.e., the standing depth jump, the triple standing jump, the vertical jump, the high jump with a flying start, kicking the ball (according to Kurelić et al., 1975) than participants with flat feet. However, the participants suffering from flat feet had better results when completing the motor tests of speed, when compared to the participants from the sub-sample who had normal (healthy) feet.

CONCLUSION

The results of this research regarding the incidence of fallen arches could be described as very unsatisfactory. The causes of the high incidence could be various: obesity, genu valgum, femoral and tibial torsional abnormalities, ligament laxity, the influence of footwear, among others. The determined problem, physiological flat feet, can be reconstituted by certain exercises (e.g. by the extension of the great toe or by standing on tiptoes). Concerning this research, medial arch improvement in relation to time needs to be monitored and analyzed. Also, further studies are needed regarding the impact of feet status on motor skills, i.e. explosive strength and speed. In terms of the applied methodology of feet status assessment, a modern computerized podoscope with associated software proved to be easy and well accepted both by researchers and the subjects.

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UČESTALOST RAVNOG STOPALA KOD UČENIKA SREDNJOŠKOLSKOG UZRASTA

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Uvod: Ravno stopalo kod dece i adolescenata, kao posledica različitih faktora, kao što su hipokinezija, prekomerna telesna težina ili nasledni faktori, predstavlja aktuelan problem. Cilj: Glavni cilj istraživanja bio je da se utvrdi učestalost ravnog stopala kod učenika srednjoškolskog uzrasta. Metode: Uzorak ispitanika sačinjavalo je 228 učenika srednje škole, muškog i ženskog pola, telesne visine 173,65±9,10 u cm, telesne težine 63,99±11,18 u kg, starosti 16,64±0,88 godina (Mean±St.Dev.). Podaci aktuelnog istraživanja deo su naučnog projekta broj 179024, finansiranog od strane Ministarstva za nauku i tehnološki razvoj Republike Srbije. Upotrebom savremenog kompjuterizivanog podoskopa "Pedic" (Mađarska) sa pripadajućim softverom, analizirane su sledeće varijable stopala: 1) PesNoL; 2) PesNoR (normalno levo i desno stopalo, respektivno) izraženo numerički sa 0; 3) PesPlL; 4) PesPlR (stepen deformiteta levog i desnog stopala, respektivno), izraženo numerički sa 1, 2, 3 ili 4. U cilju obrade podataka korišćen je paket "SPSS verzija 13", a dobijeni rezultati predstavljeni su deskriptivno i z-testom za utvrđivanje razlika između dve proporcije. Rezultati: Analizom otisaka stopala 228 ispitanika, postojanje ravnog (-ih) stopala utvrđeno je kod 111 ispitanika (48.7%), naspram 117 ispitanika (51.3%) sa normalnim stopalima, tj., bez deformiteta. Primenom z-testa za utvrđivanje razlika između dve proporcije, provereno je da li je procenat ispitanika bez utvrđenog deformiteta stopala bio statistički značajno veći od procenta ispitanika sa utvrđenim deformitetom ravnog stopala bilo kojeg stepena. Značajnost z-testa (sig=0.523), ukazala je da ne postoje statistički značajne razlike u procentima ispitanika sa normalnim i ravnim stopalima. Zaključak: Rezultati aktuelnog istraživanja u odnosu na učestalost ravnih stopala, mogu se opisati kao veoma nezadovoljavajući. Uzroci visoke utvrđene učestalosti mogu biti različiti: gojaznost, "x" noge, deformitet butne i tibijalne kosti usled torzije, "labavost" ligamenata, uticaj obuće, itd. Utvrđeni problem, fiziološki ravno stopalo, može se korigovati određenim vežbama (npr. opružanjem palca ili stajanjem na vrhovima prstiju).

Ključne reči: *ravno stopalo, učenici srednjoškolskog uzrasta, učestalost.*