

ORIGINAL ARTICLE

Medicine Science 2020;9(2):298-304

Prevalence of flatfoot in secondary school students and its relationship with obesity

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Received 03 December 2019; Accepted 14 January 2020

Available online 23.03.2020 with doi: 10.5455/medscience.2019.08.9187

Abstract

The aim of this study is to determine the flatfoot prevalence of secondary school students and to investigate the relationship between obesity. As the population of the study consists of 28540 students between the ages of 10 and 18 living in Yeşilyurt and Battalgazi districts of Malatya province, the sample consisted of 3493 people, 1593 women and 1903 men. It was found that, 16.7% of women (9.8% flexible, 6.9% rigid), 16.1% of men (9.3% flexible, 6.8% rigid) had pes planus. It was determined that 19.6% of the participants had problems in their feet and 9.7% of them had flexible, 6.9% had rigid pes planus and 3% had high arch. It was observed that 31.2% of overweight participants were flexible and 15.6% were rigid pes planus while 21.2% of the obese participants were flexible and 37.7% were rigid pes planus. The mean of visual analogue scale (VAS) scores in which the participants evaluated the pain in the lower part of the leg during the day was 6.0 ± 0.8 , in students with flexible pes planus and 8.5 ± 1.11 in students with rigid pes planus. As a result of the study, no significant relationship was found between gender and flatfoot, but there was a significant relationship between flatfoot and obesity in all age groups.

Keywords: Flatfoot, secondary education, obesity

Introduction

Flatfoot is a deformity caused by a decrease or complete collapse of the medial longitudinal arch (MLA) of the foot [1]. Also, the lack of complete formation of one or two bones in the ankle and metatarsus or their congenital attachment impacts the formation of flatfoot [2]. There are two clinical forms of flatfoot, flexible and rigid. In the literature, pain sensitivity in the foot, stiffness, antalgic gait, imbalance of the foot muscles, tension in the ligaments and quick fatigue while walking and stress fractures occur as a result of flatfoot in adults [3]. At the same time, these changes can cause foot, calf and low back pain as well as walking disorders. Therefore, flatfoot adversely affects daily activities such as doing sports, standing and walking for a long time, physical fitness and quality of life [1,4]. While the incidence of flatfoot was 7 to 22%

in some sources [5, 6], it was found to be between 1.1% and 43.2% in others [7]. Having a passive lifestyle triggers health problem such as cardiovascular diseases, obesity and diabetes in flatfooted individuals.

Although genetic factors have a significant impact, the main cause of obesity is the consumption of food that gives more energy than you needed or spent [8]. In fact, obesity may appear to be a middle age disease, it can occur at any time during lifespan. It has been suggested that most adults who are obese begin to have obesity starting from childhood or even infancy [9]. Obesity can be seen in both sexes, but there is a higher incidence of obesity among girls during primary school and puberty. In the Food Consumption and Nutrition Survey conducted in Turkey, the obesity rate was found to be 7.5% for boys and 10.4% for girls in the 6-18 age group [10].

The interaction between physical activity and energy expenditure plays an important role in the formation of obesity [11]. Inactivity, social and environmental factors triggered by the inclusion of increasing technological innovations in daily life and facilitating lifestyle of people trigger malnutrition habits and obesity, which develops due to the psychology of individuals, appear as an

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important problem during adolescence [12]. Studies on childhood obesity shows that the prevalence of obesity in this age group tends to increase in all countries [13]. In the Health Behavior in School-Aged Children Survey conducted in 41 countries, it was found that 24% of girls and 34% of boys were overweight in 13 years old group, 31% of girls and 28% of boys were overweight in 15 years old group. Obesity rate was found to be 5% in girls aged 13 and 15 years and 9% in boys [14].

Although its exact prevalence of flatfoot in children is not known well, it seems to be mostly related with obesity in school aged adolescent. If it is not treated, this condition will be constant in adulthood. Therefore, the aim of this study is to determine the prevalence of flatfoot in secondary school students and to investigate its relationship with obesity.

Materials and Methods

This is a cross sectional, descriptive type study to determine the prevalence of flatfoot in secondary school students and to investigate its relationship with obesity. As the population of the study consisted of 28540 students between the ages of 10 and 18 living in Yeşilyurt and Battalgazi districts of Malatya province, the sample consisted of 3496 students, 1593 girls and 1903 boys. The sample was chosen according to stratified sampling method. For the study, written permission and ethical approval were taken from Malatya Provincial Directorate of National Education and from the local university, respectively. Students and their parents were informed about the study and insured against any possible side effects and complications of data collection procedures. Then, informed consent forms were obtained from those who volunteered to participate in the study.

Although there are many methods currently being used to classify the MLA structures the footprint is still the most popular approach to assess and analyze the sole of the foot. Staheli index (SI) was most commonly used for clinical diagnosis by using footprint. The footprints of the students were obtained with the lux podoscope device (Chinesport, Italy) because it was reliable, simple and easy to use [15] (Figure 1).



Figure 1. Footprints obtained by podoscope device

SI was used to determine the shape of the soles of the feet as flexible or rigid [16, 17]. SI is a ratio calculated by dividing the narrowest width of the foot arch by the widest width in the heel. If this ratio

is between .50 and .70 it is considered as normal, if it is greater than .70 it is considered as flatfoot [16]. The footprints obtained by podoscope were analyzed automatically via the Global Postural System/PoData software.

In differentiating between flexible and rigid flatfoot, observation of MLA in the sitting and standing positions, measurement of heel valgus, presence of toe walking which shows stiffness in the Achilles tendon, a family history of hypermobility, foot and leg pain and a history of quick shoe wear-out were investigated. Because it was not possible to radiological evaluation, tarsal coalition was diagnosed by manual examination while the students were standing, walking, sitting, and lying position. The lack of heel inversion while standing on tiptoes also indicated a rigid flatfoot. The students were asked to stand on their feet while facing their back. After the heel assumed the valgus position and the foot arch was flattened, the subject was asked to stand on tiptoes. If the heel does not revert to its normal position or if no arch forms when the big toe retracts toward its own body or when the subject does not step on his foot, it is considered as rigid flatfoot [18,19].

Sex, age, and dominant side of each student were recorded. The height of the students was measured with a sock or barefoot using a wall-mounted stadiometer with a precision of 0.01 cm and weight was measured with 0.01 kg precision scale (Teca, Germany) and light clothes such as t-shirts and shorts. Height and weight measurements of the students were taken by two different researchers. Each student was measured twice by the researchers. If there was a difference between the measurements, a third measurement was taken and the average of the three measurements was recorded.

The body mass index (BMI) was calculated by dividing the weight in kilograms by the square of the height in meters and evaluated by BMI percentile [20]. Finally, visual analogue scale (VAS) was used to determine activity related pain in the students' foot and ankle. Ten point Likert-type scale was used as self-reported measurements of pain in the foot and ankle. Number 0 indicated "no pain" and 10 showed "an intense pain". The middle value, 5, in the scale is often labelled as a neutral or moderate condition therefore any response above this value considered as a certain degree of pain [21].

Statistical analysis of the data was performed by IBM Statistics (SPSS version 21.0, Armonk, NY) package. Since the data obtained did not show a normal distribution, chi-square test was used to analyze the data and findings were presented as cross tables, percentage and frequency.

Results

A total of 3496 students (1903 boys (54.4%), 1593 girls (45.6%)) aged between 10 and 18 participated in the study. The mean age of the students was 14.03 ± 2.58 years old for boys and 14.10 ± 2.62 years old for girls. It was found that 4.06% of the participants were underweight, 71.28% were normal weight, 17.22% were overweight and 7.44% were obese. At the end of data analysis, no significant relationship was found between gender and flatfoot, but there was a significant relationship between flatfoot and obesity in all age groups. The flatfoot status of primary, secondary and high school students are given in separate tables below.

Table 1. Prevalence of flatfoot in 10 years of age

Age	BMI	Normal		Flexible		Rigid		High arch		Total		χ^2	df	p
		n	%	n	%	n	%	n	%	n	%			
10	Underweight	8	88.9	1	11.1	-	-	-	-	9	100	85.826	9	.000*
	Normal	265	84.9	28	9.0	15	4.8	4	1.3	312	100			
	Overweight	11	34.4	7	21.9	14	43.8	-	-	32	100			
	Obese	-		2	100	-	-	-	-	2	100			
	Total	284	80.0	38	10.7	29	8.2	4	1.1	355	100			

*p<.05

According to Table 1, 11.1% of the underweight, 21.9% of the overweight and all of the obese participants (100%) had a flexible flatfoot, whereas 4.8% of the normal weight and 43.8% of the overweight participants in 10 years old had rigid flatfoot. Chi-square test revealed a significant relationship between 10 years of age variable and presence of flatfoot ($\chi^2(df=9, n=355)=85.826, p=.000$).

Table 2. Prevalence of flatfoot in 11-14 age group

Age	BMI	Normal		Flexible		Rigid		High arch		Total		χ^2	df	p
		n	%	n	%	n	%	n	%	n	%			
11	Underweight	10	100	-	-	-	-	-	-	10	100	333.104	9	.000*
	Normal	338	92.6	-	-	17	4.7	10	2.7	365	100			
	Overweight	17	31.5	24	44.4	13	24.1	-	-	54	100			
	Obese	3	15.8	-	-	16	84.2	-	-	19	100			
	Total	368	82.1	24	5.4	46	10.3	10	2.2	448	100			
12	Underweight	27	96.4	-	-	-	-	1	3.6	28	100	260.422	9	.000*
	Normal	226	90.0	19	7.6	3	1.2	3	1.2	251	100			
	Overweight	20	32.3	36	58.1	6	9.7	-	-	62	100			
	Obese	2	11.1	3	16.7	13	72.2	-	-	18	100			
	Total	275	76.6	58	16.2	22	6.1	4	1.1	359	100			
13	Underweight	8	100	-	-	-	-	-	-	8	100	235.942	9	.000*
	Normal	241	95.3	4	1.6	-	-	8	3.2	253	100			
	Overweight	13	24.1	14	25.9	27	50.0	-	-	54	100			
	Obese	2	10.0	7	25.0	11	55.0	-	-	20	100			
	Total	264	78.8	25	7.5	38	11.3	8	2.4	335	100			
14	Underweight	19	100	-	-	-	-	-	-	19	100	163.234	9	.000*
	Normal	243	94.2	6	2.3	-	-	9	3.5	258	100			
	Overweight	40	63.5	20	31.7	3	4.8	-	-	63	100			
	Obese	12	36.4	11	33.3	10	30.3	-	-	33	100			
	Total	314	84.2	37	9.9	13	3.5	9	2.4	373	100			

*p<.05

The prevalence of flatfoot in secondary school children aged between 11 and 14 years old was presented in Table 2. According to the results, there was a significant relationship between BMI of primary school children and the presence of flatfoot in all age categories ($p=.000$). Of the participants who were 11 years old, 44.4% of those who were overweight had a flexible flatfoot, 4.7% of those who were normal weight, 24.1% of those who were overweight and 84.2% of those who were obese had a rigid flatfoot (χ^2 (df=9, n=448) =333.104, $p=.000$).

22.3% of the 12-years-old participants were flat feet. 7.6 % of normal weight, 58.1% of overweight and 16.7% of obese participants had a flexible flatfoot but 1.2% of normal weight, 9.7% of overweight and 72.2% of obese participants had a rigid flatfoot. The relationship between the BMI of 12 years old participants and

presence of flatfoot was significant (χ^2 (df=9, n=359) =260.422, $p=.000$).

In participants who were 13 years old, flexible flatfoot found with 1.6% in normal weight, 25.9% in overweight and 35% in obese participants. However, rigid flatfoot seen at 50% in overweight and 55% in obese participants was statistically significant (χ^2 (df=9, n=335) =235.942, $p=.000$).

According to the results, of the participants who were 14 years old, 2.3% of those who were normal, 31.7% of those who were overweight and 33.3% of those who were obese had a flexible flatfoot. However, 4.8% of the participants who were overweight and 30.3% of those who were obese had a rigid flatfoot as seen in Table 2 (χ^2 (df=9, n=373) =163.234, $p=.000$).

Table 3. Prevalence of flatfoot in 15-18 age group

Age	BMI	Normal		Flexible		Rigid		High arch		Total		χ^2	df	p
		n	%	n	%	n	%	n	%	n	%			
15	Underweight	28	93.3	1	3.3	-	-	1	3.3	30	100	92.624	9	.000*
	Normal	284	89.6	23	7.3	4	1.3	6	1.9	317	100			
	Overweight	43	71.7	3	5.0	14	23.3	-	-	60	100			
	Obese	13	50.0	3	11.5	10	38.5	-	-	26	100			
	Total	368	85.0	30	6.9	28	6.5	7	1.6	433	100			
16	Underweight	12	100	-	-	-	-	-	-	12	100	163.234	9	.000*
	Normal	275	97.9	1	0.4	3	1.1	2	0.7	281	100			
	Overweight	55	61.8	31	34.8	3	3.4	-	-	89	100			
	Obese	25	53.2	13	27.7	9	19.1	-	-	47	100			
	Total	367	85.5	45	10.5	15	3.5	2	0.5	429	100			
17	Underweight	11	78.6	-	-	-	-	3	21.4	14	100	195.874	9	.000*
	Normal	186	97.9	2	1.1	-	-	2	1.1	190	100			
	Overweight	43	52.4	32	39.0	7	8.5	-	-	82	100			
	Obese	24	55.8	4	9.3	15	34.9	-	-	43	100			
	Total	264	80.2	38	11.6	22	6.7	5	1.5	329	100			
18	Underweight	12	100	-	-	-	-	-	-	12	100	103.370	9	.000*
	Normal	252	95.1	5	1.9	5	1.9	3	1.1	265	100			
	Overweight	78	73.6	21	19.8	7	6.6	-	-	106	100			
	Obese	26	50.0	12	23.1	14	26.9	-	-	52	100			
	Total	368	84.6	38	8.7	26	6.0	3	0.7	435	100			

* $p<.05$

The prevalence of flatfoot in high school children aged between 15 and 18 years old was presented in Table 3. Of the participants who were 15 years old, 3.3% of those who were underweight, 7.3% of those who were normal, 5.0% of those who were overweight and 11.5% of those who were obese had a flexible flatfoot, whereas 1.3% of the normal weight, 23.3% of the overweight and 38.5% of obese participants had rigid flatfoot (χ^2 (df=9, n=433) =92.624, p=.000).

In those who were 16 years of age, 0.4% of normal, 34.8% of the overweight and 27.7% of obese participants had a flexible flatfoot, whereas 1.1% of the normal weight, 3.4% of the overweight and 19.1% of obese participants had rigid flatfoot (χ^2

(df=9, n=429) =163.234, p=.000).

Of the subjects who were 17 years old, 21.4% of the underweight had a high arch, 1.1% of the normal, 39.0% of the overweight and 9.3% of the obese participants had a flexible flatfoot, whereas, 8.5% of the overweight and 34.9% of obese participants had rigid flatfoot (χ^2 (df=9, n=329) =195.874, p=.000).

Table 3 shows that 14.7% of the 18-years-old participants are flat feet. 1.9% of normal weight, 19.8% of overweight and 23.1% of obese participants had a flexible flatfoot, but 1.9% of normal weight, 6.6% of overweight and 26.9% of obese participants had a rigid flatfoot (χ^2 (df=9, n=435) =103.370, p=.000).

Table 4. Prevalence of flatfoot based on the BMI of the participants

Age	BMI	Normal		Flexible		Rigid		High arch		Total		χ^2	df	p
		n	%	n	%	n	%	n	%	n	%			
10	Underweight	135	95.1	2	1.4	-	-	5	3.5	142	100	1138.285	9	.000*
	Normal	2310	92.7	88	3.5	47	1.9	47	1.9	2492	100			
	Overweight	320	53.2	188	31.2	94	15.6	-	-	602	100			
	Obese	107	41.2	55	21.2	98	37.7	-	-	260	100			
	Total	2872	82.2	333	9.5	239	6.8	52	1.5	3496	100			

*p<.05

According to the Table 4, there was also a significant relationship between the BMI of the participants and presence of flatfoot (χ^2 (df=9, n=3496) =1138.285, p=.000). Incidence of flexible flatfoot was 1.4% for underweight, 3.5% for normal, 31.2% for overweight and

21.2% for obese students, whereas the prevalence of rigid flatfoot was 1.9% for normal, 15.6% for overweight and 37.7% for obese participants.

Table 5. Prevalence of flatfoot based on the gender of the participants

Age	Gender	Normal		Flexible		Rigid		High arch		Total		χ^2	df	p
		n	%	n	%	n	%	n	%	n	%			
10	Girls	1303	81.8	156	9.8	110	6.9	24	1.5	1593	100	.293	3	.961
	Boys	1569	82.4	177	9.3	129	1.9	28	1.5	1903	100			
	Total	2872	82.2	333	9.5	239	6.8	52	1.5	3496	100			

*p<.05

Table 5 shows the prevalence of flatfoot based on the gender of the participants. When the results were examined, it was found that 9.5% of the participants (9.8% girls, 9.3% boys) had a flexible and 6.8% of those (6.9% girls, 6.8% boys) had a rigid flatfoot. The incidence of high arch was very low with 1.5% in both girls and boys. No significant relationship was detected between gender and presence of flatfoot (χ^2 (df=3, n=3496) =.293, p=.961).

Finally, the mean VAS scores of the participants with normal, flexible, rigid and high-arch foot were 2.96 ± 1.39 , 6.0 ± 0.08 , 8.5 ± 1.11 and 5.44 ± 1.15 , respectively.

Discussion

Obesity seen in adolescence is an important health problem in terms of affecting the whole life of the individual. Although there are many studies investigating the medical causes and complications of obesity in adults, the number of studies in adolescents is very limited.

In a study of 1044 adolescents in the 12-13 age group in Istanbul, Ankara and Izmir, it was found that 12% of children were overweight and 2% were obese [14]. Similarly, in a study conducted with 2671 children in the 11-17 age group in Kayseri, it was stated that 10.6%

of the children were overweight and 1.6% were [22]. In a study conducted in Muğla, 4260 children between the ages of 6-15 were evaluated for obesity and it was shown that 7.6% of girls and 9.1% of boys were obese [23]. In a study conducted on 4120 secondary and high school students in Samsun province, the prevalence of obesity was found to be 7.3% in girls and 4% in boys. [24]. The increasing prevalence of obesity in adolescents clearly shows how important it is to fight with obesity in the early period because it may cause many health complications in adulthood.

As the obesity rate in Turkey was 15.2% in 2008, this ratio increased by 31.1% in 2014 and reached 19.9%. The increase rate was 32.3% for women and 24% for men. The highest obesity rate is seen in the USA with 28.7%. While the USA is followed by Iceland with 22.2%, Turkey is also ranked third with 19.9% obesity rate [25]. One of the most important factors triggering this situation is the inactive life style. Flatfoot increases the prevalence of overweight or obesity as it forces individuals to live a more passive or inactive life.

In our study, 16.7% of girls (9.8% flexible, 6.9% rigid flatfoot) and 16.1% of boys (9.3% flexible, 6.8% rigid flatfoot) were found to be flatfoot. These results show that there is no difference in the prevalence of obesity between the genders in secondary school students. Similar to our results, there are some studies in obese adolescents with no gender differences [26]. In another study, no significant difference was found between genders in obese adolescents [27]. However, contrary to our findings, according to studies conducted in Canada [28, 29, 30], the prevalence of obesity was found to be higher in girls. When the studies in the literature are examined, it is understood that there is no clear relationship between obesity prevalence and gender.

The prevalence of flatfoot was 17.8% (9.5% flexible, 6.8% rigid and 1.5% high arch) among students and 58.8% (21.2% flexible and 37.7% rigid) of obese students and 46.8% (31.2% flexible and 15.6% rigid) of overweight students were flatfooted (Table 4).

While the mean VAS score of the students with flexible flatfoot was 6.0 ± 0.8 , it was 8.5 ± 1.11 for the students with rigid flatfoot. Research has shown that obese people experience more musculoskeletal, knee and back pain than non-obese people [19]. Foot pain has been reported to be a common musculoskeletal complaint especially in obese adults and children [31]. In a study of 2,179 people in Denmark, it was reported that BMI of people with foot pain was also significantly higher [32].

Obesity adversely affects musculoskeletal system and excessive weight increases the mechanical pressure on the joints and tissues of the body, causing physical restraints and pain [33, 18]. Self-reported somatic pain symptoms increase with increasing BMI values, and the combination of pain and weight-related physical disorders exacerbates the decline in physical functions [34, 35]. Therefore, detection of high rate of flatfoot in secondary school children can be expressed as the onset of many ailments in subsequent years.

Finally, at the end of the study, no significant relationship was found between gender and flatfoot, while there was a significant relationship between flatfoot and obesity in all age groups in secondary school students.

Conclusion

Explaining the importance of shoe selection and the use of insoles and suggesting exercises strengthen the foot muscles could minimize the postural deformities and / or muscle shortness in flatfooted individuals.

As a conclusion, it is known that foot sole deformity negatively affects daily life, quality of life and physical fitness parameters of individuals. Therefore, it is very important to start preventive or protective approaches and practices related to foot health in the early period to prevent flatfooted individuals from encountering many problems in the future. Further prospective studies investigating the foot posture and function are also needed to better understand the etiology of foot problems and related outcomes.

Competing interests

The authors declare that they have no competing interest.

Financial Disclosure

This study received no financial support.

Ethical approval

For the study, written permission and ethical approval were taken from Malatya Provincial Directorate of National Education and from the local university, respectively. (IRB number: 2019/0483).

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