

Relationship between Obesity and Flatfoot in High-school Boys and Girls

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ABSTRACT. The purpose of this study was to determine the relationship between obesity and flatfoot among high – school students in Rasht (North Province of Iran). 1180 students (726 boys and 454 girls) were selected cluster random sampling. Height and weight of subjects were measured by using standard apparatus. BMI (weight / height²) was considered as the index of obesity .The international BMI cut – off values was used to determine obesity (BMI> 95th percentile), and foot structure assessment was performed with Denis Method. No significant relationship between obesity and flatfoot was observed. A significant difference ($P \leq 0.05$) was found between the prevalence of flatfoot and age in boys and girls in age 12 – 15 years, but for age 16 and 17 years no significant difference was observed. In conclusion, the results of this study suggest increasing of weight temporarily, may cause existence significant difference in the prevalence of flatfoot among high - school boys and girls in age 12 – 15 years. Because most of girls in our study experienced puberty in age 12 – 15 years.

Key words: Body mass index, Foot structure, Age groups, Weight classes, plantar footprint.

1. Introduction

Feet, as the body's base of support, continually endure often high ground reaction forces generated during activities of daily living. The component primarily responsible for the feet is absorbing and dissipating these forces in the longitudinal arch [1]. Although this arch comprises bony articulations ligaments and muscles, it is primarily the ligaments that support and stabilize the longitudinal arch, as well as acting as powerful energy-storing mechanisms [2, 3]. Muscles provide secondary support by maintaining the arch during dynamic tasks. Ligaments rarely incur physiological fatigue and therefore offer a greater resistance to stress compared to muscles [1]. Flatfoot is often a complex disorder, with diverse symptoms and varying degrees of deformity and disability. There are several types of flatfoot, all of which have one characteristic in common—partial or total collapse (loss) of the arch [2,4]. Flexible flatfoot is one of the most common types of flatfoot. It typically begins in childhood or adolescence and continues into adulthood. It usually occurs in both feet and generally progresses in severity throughout the adult years. As the deformity worsens, the soft tissues (tendons and ligaments) of the arch may stretch or tear and can become inflamed [2, 4].

It has been reported that flat feet in children are normal when they first begin to stand because as they try to keep balance and grip with the feet for support, they tend to spread apart in a wide stance and the soles turn outward. Balancing in a narrower stance as confidence is gained in standing; Causes of the persistence of flat feet; Tips on how to prevent pigeon-toed walking in children [5].The feet of most children who displayed the condition as infants become structurally normal when they are 12 or 13 years old [6].

Many different factors can contribute to the development of flat feet. These include overweight, the types of shoes a child wears, a child's sitting or sleeping positions, compensation for other abnormalities further up the leg, or more severe factors such as rupture of ligaments or tendons in the foot [4]. However, repeated excessive loading may stretch ligaments beyond their elastic limit, damaging soft tissues and increasing the risk of foot discomfort and subsequent development of foot pathologies [1].

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Increased loading of the feet may be classified according to time-frame and described as temporary, short-term or long-term. A temporary loading effect occurs, for example, when carrying a backpack or wearing a weighted belt that temporarily increases body mass. In contrast, a long-term loading effect occurs over an extended period, such as in obesity, where the increase in mass is continuous [1]. Although studies pertaining to temporary and short-term loading effects on lower limb and foot mechanics are available [7, 8] minimal research has examined the long-term loading effects of obesity on the musculoskeletal system, particularly in reference to the feet [1]. Obesity and overweight during the developmental years are related to certain dimorphisms of the foot, in particular with flat foot [9]. Various authors also have suggested that excessive increases in weight bearing forces caused by obesity may negatively affect the lower limbs and feet [10, 11].

Garcia- Rodriguez et al., (1999) estimated the prevalence of flexible flat feet in the provincial population of 4 to 13 year old schoolchildren and the incidence of treatments considered unnecessary [6]. They reported that the prevalence of flat feet was 2.7% of the 1181 children sampled, 168 children (14.2%) were receiving orthopedic treatment, but only 2.7% had diagnostic criteria of flat feet. When they inspected the sample, they found that a number of children were being treated for flat feet with boots and arch supports. Most of them did not have a flat plantar footprint according to the criteria that they used for this work. Furthermore, in the group of children that they diagnosed as having flat feet, only 28.1% were being treated. They found no significant differences between the number of children receiving orthopedic treatments and the presence or absence of a flat plantar footprint. Children who were overweight in the 4 and 5 year old group showed an increased prevalence for flat feet as diagnosed by them [6].

Bordin et al., (2001) reported that the incidence of flat foot in the population studied was found to be 16.4%, of which 18.1% were males and 14.6% females. Fifty percent showed slight flat-footedness (1st degree), 28% moderate (2nd degree) and 22% showed very marked flat-footedness (3rd degree). The frequency of obesity and overweight in the same population was found to be 27.3% (Cole index >120). An analysis of the variance showed a significant difference between the Cole Index in subjects with flat feet (121.77 ± 19.2) and the rest of the population examined (110.12 ± 15.3). In this study, the children suffering from this dysmorphism were also found to be obese or overweight [9].

However, despite the potential negative consequences of obesity on lower limb structure, only one investigation, from the same laboratory, has considered the effects of obesity on foot structure in children. Riddiford - Harland et al (2000) examined the foot structure of 62 obese (body mass index (BMI) >95th percentile) and 62 non-obese (10th percentile < BMI < 90th percentile) prepubescent children (mean age 8.5 ± 0.5 y) [12]. Foot structure was characterized using the same techniques as in the current study, the footprint angle (FA) and Chippaux - Smirak index (CSI) [13]. The authors found a significant difference between the FA of the obese and non-obese subjects for both the left and right feet whereby the obese children displayed a reduced angle. Furthermore, CSI scores for the left and right feet were significantly greater in the obese children. A decreased FA and an increased CSI are characteristics of structural foot changes, such as lowered longitudinal internal arches, a flatter cavity and a broader mid foot area of the footprint, that have been associated with compromised foot function. For example, lower arches have been associated with a decrease in the integrity of the foot as a weight-bearing structure [12]. From these results Riddiford - Harland et al., (2000) concluded that excess body mass appeared to negatively affect the foot structure of prepubescent children whereby obese children as young as 8 y of age were displaying structural foot characteristics which may develop into problematic symptoms if excessive weight gain continued [12].

It was also postulated that foot discomfort associated with higher plantar pressures caused by these structural changes in the obese foot may have hindered obese children from participating in physical activity and therefore warranted immediate further investigation [12]. Although providing comprehensive data pertaining to the effects of obesity on foot contact area, the Riddiford - Harland et al., (2000) study was restricted to a static analysis of external foot structure and did not examine the pressures exerted on the plantar surfaces of the children's feet [12]. Consequently it is unknown whether the significant changes to the external foot structure noted by Riddiford - Harland et al., (2000) were associated with an increased loading per unit area under the feet of these obese children [12]. Therefore, the purpose of the present study is to estimate the prevalence of flat feet in high – school students, to determine the relationship between flat foot and obesity, and to compare prevalence of flat foot among high – school boys and girls.

2. Method

2.1. Subjects

The study population consisted of high – school girl students (41511) and boy students (39862) that educated during 2003 – 2004. Out of a total of population, 382 samples were considered according to Udinsky sample estimation table [14]. Finally, 726 boys and 454 girls participated in the study. A two stage stratified cluster sample was selected. The sample units at the first stage were the school at the north, south, east, west and center of city. The frame for the selection of the primary sampling units was based on a list provided by educational authorities in Rasht city. The second stage was sampling 20 students within classes in the schools.

2.2. Procedures

Before the study began, the school authorities met, explained the purpose of the study and sought their consent. Agreement was reached on conducting the study, with due regard for national ethics, local customs and parents wishes. Researchers sent on preplanned scheduled visits, at the convenience of the school authorities, with least disturbance of the students.

The following information was recorded from each subject: date of birth, school name, grade, height and weight.

Height and weight were measured on subject in light clothes and without shoes using standard apparatus. The weighting scale used could be read to the nearest 0.1 kg. It was calibrated at the beginning of each working day and at frequent intervals throughout the day.

Height was measured to the nearest 0.5 cm, using a measuring tape. To measure height, the measuring tape was fixed to the wall. Height was measured while the subject stood with heels, buttocks, shoulders and occiput touching the vertical tape. The head was held erect with the external auditory meat us and the lower border of the orbit in one horizontal plane. All measurements were taken by one of the authors.

Subjects were classified as underweight, desirable weight, overweight and obesity groups using the international cut – off for body mass index (BMI) as follow [15, 16]. Cut – off values : underweight (15th percentile < values), desirable weight (15th – 85th percentile), overweight (85th – 95th percentile) , and obesity (values > 95th percentile) . BMI (kg / m²) was calculated as weight (kg) divided by square of the height (m) . According to following classification: underweight < 20, desirable weight 20 – 24.9, overweight 25- 29.9, and obesity ≥ 30. But, this classification is commonly used to classify weight classes among adults and is also recommended to identify children and adolescents' weight status based on cut – off BMI [17]. Also, Foot structure assessment was performed with Denis Method [18].

Prior to testing, the children's feet were screened by a podiatrist to identify and exclude subjects with any external factors that may have contributed to variations in plantar pressures, such as calluses. All subjects underwent footprint and medical history screening, too. The exclusion criteria were foot injury including any bony pathology or ligament injury, degenerative or rheumatoid arthritis and other musculoskeletal abnormalities that were previously evaluated during physical examination or plain X-ray.

To assess static plantar footprint, each subject stood barefoot and relaxed in the anatomical position, adopting the same posture used to collect footprint data by chalking the sole of the foot and making an impression of it on paper. The plantar footprint was classified according to Denis into three grades of flat feet: grade 1 in which the support of the lateral edge of the foot is half of that of the metatarsal support; grade 2 in which the support of the central zone and forefoot are equal; and grade 3 in which the support in the central zone of the foot is greater than the width of the metatarsal support [18]. This is described in detail in [Fig 1](#).

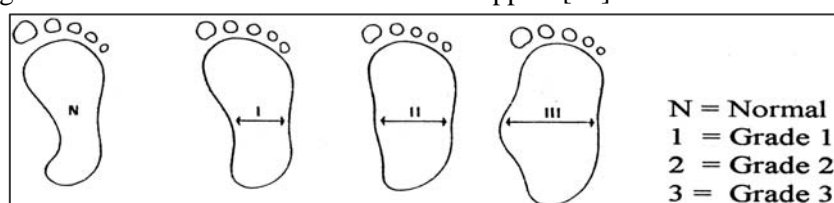


Fig.1. Classification of plantar footprint according to Denis Method [18].

In this study, we defined those children who displayed a second or third degree plantar footprint as flat-footed. Children with first degree plantar footprints were not included in this study, because they were considered to have evolutionary foot problems without pathologic significance according to Meary and Stewart [19, 20].

2.3. Statistical analysis

Data analyzed with SPSS version 10 packages. Mean and standard deviation (SD), and frequency was calculated and differences were analyzed using chi – square test analysis for arch index. The results are given in 95% confidence interval (CI). 95% CI were estimated by confidence Interval Analysis Software [21]. All tests for statistical significance were two tailed and performed at $\alpha < 0.05$.

3. Results

A total of 726 boys (age = 15 ± 2 yrs) and 454 girls (age = 14 ± 2 yrs) were included in the study. The mean and SD of weight, height and BMI measurements are shown in table 1.

Table 1. Characteristics of subjects (Mean \pm SD)

Measurement	Boys	Girls
Weight (kg)	53.2 \pm 11.9	50.3 \pm 11.5
Height(cm)	162.3 \pm 8.9	156.2 \pm 15.6
BMI	19.9 \pm 4.3	20.4 \pm 4.1

Table 2 shows the prevalence of flat foot in girls and boys. The prevalence of flat foot was 28.7% in boys and 15.2% in girls.

Table 2. The prevalence of flat foot in girls and boys

	N	%
Boys	208	28.7
Girls	69	15.2

The mean and SD of BMI in girls (20.4 \pm 4.1) and boys (19.9 \pm 4.3) is about desirable range. However as have been shown in table 3, the range of underweight in boys (29.9%) is greater than girls (13.9%) and range of total of overweight and obesity in boys (17.4%) is very close to girls (18.7%).

Table 3. Weight classes in high – school boys and girls

Weight class	<u>Boys</u>		<u>Girls</u>	
	N	%	N	%
Underweight	217	29.9	63	13.9
Desirable weight	383	59.8	306	67.6
Overweight	79	10.9	56	12.3
Obesity	47	6.5	29	6.4
Total	726	100	454	100

Table 4, compares the prevalence of flat foot among boys and girls by age classes. We examined 1180 pupils who were separated into three 2-year age groups 12 and 13 years, 14 and 15 years, and 16 and 17 years (Table 5). The children were divided also into groups of boys and girls. When the different sample

groups were separated clearly, we established an experimental protocol that used several variables such as age, height, weight, and other variables that are associated directly with the foot such as plantar footprint and BMI.

Table 4. The prevalence of flat foot among boys and girls by age classes

Age classes (years)	<u>Boys</u>		<u>Girls</u>	
	N	%	N	%
12	43	35.8	17	19.5
13	35	29.1	11	14
14	29	24.4	5	7
15	57	25	9	11.9
16	32	26.7	10	15.8
17	39	30.7	14	28

Table 5. The prevalence of flat foot in age groups

Age (years)	Normal Feet (%)	Flat Feet (%)
12-13	73.9	26.1
14-15	81.1	18.9
16-17	74.4	25.6

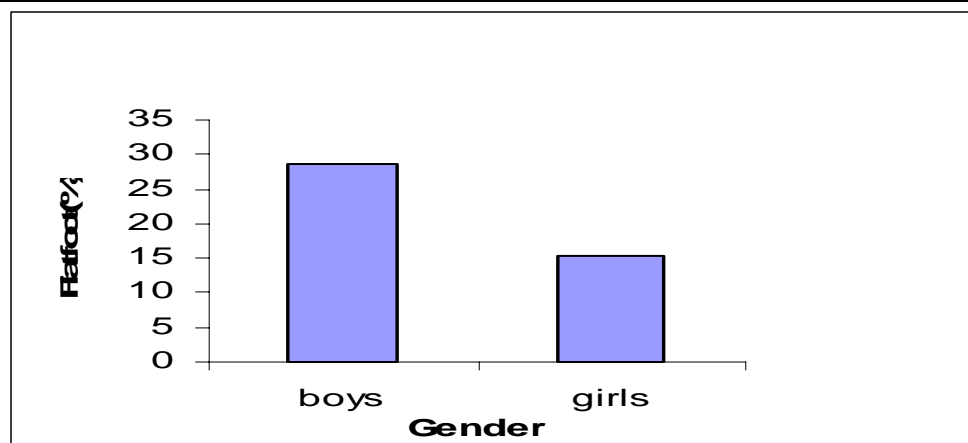


Fig.2. The prevalence of flat foot in girls and boys

The prevalence of flat feet in our series was 23.5 % (Fig 2). This differs greatly from the prevalence of 12.3% that was already reported [9]. Our analysis of data aimed to determine whether the existence of flat feet was related to the presence or absence of other independent variables that may cause the development or evolution of flat feet .So, the effect of obesity on the incidence of flat feet was calculated by using the body mass index. We found no significant relationship in our series. When we analyzed the prevalence of flat foot among boys and girls in different ages (12-17 years), we

understood that there is significant differences ($p \leq 0.05$) between the prevalence of flat foot and age in boys and girls in age 12-15 years and there is no significant differences between them in age 16 and 17 years (Fig 3).

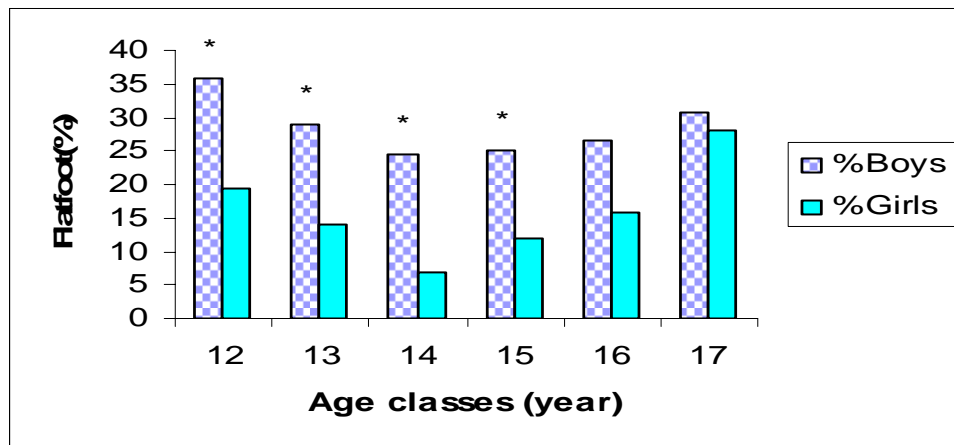


Fig.3. Relationship between flat feet and age (* $P < 0.05$)

4. Discussion & Conclusions

It has been revealed that there is a great variation in the prevalence of flexible flat feet reported by different authors [22, 23]. In our opinion, these differences could be explained by the fact that the authors used different age groups or perhaps only made their diagnosis at the end of the usual evolutionary period when additional evolution toward healthy feet was improbable. Garcia states that the critical age for development of the plantar arch is 6 years, and consequently, if the prevalence of flat feet is evaluated before this age, the finding will overestimate the problem [6].

In the static condition increased mass, whether it is temporary or long-term (obesity) caused a greater peak force to be exerted on the soles of the feet of prepubescent children while they were standing. Although a significant effect of obesity was found for the static peak areas, increasing mass temporarily in the loaded condition did not significantly alter the peak contact area between the plantar surface of the feet and the platform during static trials [1].

In this study, Static weight-bearing footprints for the right and left foot of each subject were recorded by chalking the sole of the foot and making an impression of it on paper. All of girls experienced puberty, but some boys did not. So, obesity is a temporary factor in our study that may cause the lack of significant relationship between flat foot and obesity. Because temporary mass increases resulted in increased static and dynamic plantar pressures, but no significant change to the structure of the feet. However, long-term mass increases associated with obesity appeared to flatten the medial longitudinal arch of the children as confirmed by an increased area of foot contact with the ground [1]. Increasing of temporary mass ,may cause existence significant differences in the prevalence of flat foot among high – school boys and girls in age (12-15years) and the lack of significant differences between them in age (16 and 17 years) .

In conclusion, prevalence of overweight is an important topic in age 12 – 15 years. Although it is temporary but it can be the cause of flatfoot. Therefore parents should pay attention to overweight in these ages.

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