Prevalence of flatfoot among school students and its relationship with BMI

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ABSTRACT

Objective: The aim of this study was to analyze the relation between the flat-footedness and obesity.

Materials and Methods: A total of 1158 school children (653 male and 505 female) participated in this cross sectional descriptive study. According to their age, children were divided into three groups for each gender (6–10, 11–13, 14–18 years old). Diagnosis and severity of flatfoot was assessed in using the Dennis method. BMI of children were calculated as body weight divided by height squared (kg m⁻²).

Results: Majority (83.9%) of respondents had normal feet. The prevalence of flatfoot was 16.1% with a decreasing trend with age. Boys had a higher frequency of flatfoot than girls; however the difference was not significant (p > 0.05). The prevalence of flatfoot was 17.5% in boys and 14.5% in girls. The percentage of overweight and obese children was 10.3%. A significant difference in the prevalence of flatfoot occurred between; under-weight (13.9%), normal-weight (16.1%), overweight (26.9%), and obese (30.8%); children.

Conclusion: The increasing prevalence of childhood obesity is one of the most serious health challenges across the globe, and a positive correlation between increased BMI; and flatfoot is one of the potential complications.

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Feet, the body's base of support, are comprised of some bones arranged and connected together by muscles and ligaments. There are three arches in the foot, which are referred to as the longitudinal medial arch, longitudinal lateral arch, and the transverse arch. These arches, mainly the medial longitudinal arch, absorb the weight pressure.1 Laxity of the ligaments or weakness of the foot muscles may shorten the length of the medial longitudinal arch.

Flatfoot is a medical condition in which the foot does not have a normal medical longitudinal arch while standing.2,3 Due to baby fat, infants are born with flat feet. Later during childhood, the longitudinal arch develops naturally. When children begin standing on their feet, flatfoot becomes diagnosable. Flatfoot has multiple etiologies and it may lead to pain in the heel, knee, hip, and the back. It may also cause other problems such as bunions, hammer-toes, and shin splints.4

Flatfoot may be congenital or acquired.5 Congenital flatfoot is divided into two types; flexible and stiff. In flexible flatfoot, there is a medial longitudinal arch in the foot when it is not bearing any weight but the arch disappears when standing. In stiff flatfoot, the medial longitudinal arch is absent even in a non-weight-bearing situation. In acquired flatfoot, children with normal feet acquire flatfoot while growing up. Flatfoot can be caused by many factors, including obesity, wears and shoes, sitting and sleeping positions of a child, abnormality in the lower limbs, weakness of the muscles and ligaments, and tendon tear.6

Body Mass Index (BMI) is a tool for the evaluation of healthy body weight. BMI calculates the ratio of a person's weight to his/her height squared and enables us to identify obesity. It has been shown in several reports that overweightness and obesity may affect the foot structure in children.7,8 However, some researchers have recounted that there is no association between obesity and flatfoot. As an example, Atamturk reported that the change of arch height is not related to body weight and is rather associated only with the heel width.9

According to duration, load-bearing on feet is categorized into temporary, short and long-term loading.7 A person's BMI may increase temporarily if he/she is carrying something for a short period of time. Short-term indicates when someone's BMI is increased for a longer period of time, such as during pregnancy. Long-term means that a person's BMI has increased permanently due to overweightness or obesity. Zhang et al reported that the...
prevalence of increased BMI among public school children in Mississippi ranged from 22% to 43% between 2005 and 2013.10 There is a wide variation in the prevalence of flatfoot in certain reports. Gracia et al reported that the prevalence of flatfoot in children aged 4 to 13 is 2.7%.11 Bordin et al showed the prevalence of flatfoot as 16.4% and the rate of overweightness as 27.3% in Italian school children.12 A study in Taiwan demonstrated that the prevalence of flatfoot in elementary school children was 59%, the majority of which are males.13

As the prevalence of flatfoot around the world varies, the aim of this study was to determine the prevalence of flatfoot among school children in the city of Babol in Iran and the correlation between obesity and flatfoot.

Patients and methods

All school students from Babol who met the inclusion criteria were included in the study. Students with a musculoskeletal disorder, such as genu valgum, genu varum, genu recurvatum, unequal lower limbs, or scoliosis were excluded. In this cross-sectional descriptive study, 1158 school children from six randomly chosen schools (653 males, 505 females; mean age: 11.95 ± 3.57 years) were included. The participants comprised 2% of the student population in Babol. The children were divided into two groups based on their gender and each gender group was divided into three groups based on age (6–10, 11 to 13, and 14–18 years old). Approval was obtained from the Research Ethics Committee of the Babol University of Medical Sciences.

Flatfoot assessment

The pedograph was prepared using a canopy placed over a smooth, non-villous carpet. The canopy was placed on the floor, with a white sheet under for each foot. The subject stood on the canopy barefoot and in a stable position. The sole of the foot was then printed on the sheet. Consequently, the diagnosis and the severity of the flatfoot was assessed using the Denis method (Fig. 1).14

- Grade 1 flatfoot (Ff1) – the support on the lateral edge of the foot is half that of the metatarsal support
- Grade 2 flatfoot (Ff2) – the support on the central zone and forefoot are equal
- Grade 3 flatfoot (Ff3) – the support on the central zone of the foot is greater than the width of the metatarsal support

Body mass index

The height of each subject was measured to the nearest 0.1 cm, using a portable stadiometer (in the anatomical position) and the weight was measured to the nearest 0.05 kg, using a calibrated electronic scale, with the subject wearing minimal clothing. The BMIs of the children were calculated by dividing the body weight by the square of height (kg/m²). The subject was considered underweight if the BMI was less than 18.5, normal weight if the BMI was between 18.5 and 24.9, overweight if the BMI was between 25 and 29.9, and obese if the BMI was 30 or greater.

Statistical analysis

Frequencies of the variables were calculated using the SPSS for Windows v.19 software and statistical significance was evaluated using the Spearman rank-order correlation, ANOVA and chi-square analyses. Hierarchical multiple regressions was utilized to explore the predictors of flatfoot. Level of significance was set at p < 0.05.

Results

Regarding their level of education, 421 of the participants (36.4%) attended an elementary school, 309 (26.7%) attended a guidance school and 428 of them (37%) studied in high school. The mean weight and height were 43.35 ± 1.78 kg and 1.47 ± 0.19 m, respectively. Majority (83.9%) of the participants had normal height and weight and obese students was 10.3%. There was a significant difference between boys and girls; however, the difference was not significant (17.5% vs. 14.5%, p > 0.05). The Kruskal–Wallis test showed significant differences in the foot stance among different age groups (p = 0.002); as Ff1 (flatfoot) and Ff2 were more prevalent in those aged between 6 and 10 and Ff3 was observed only in a 13-year-old girl (Table 2).

In terms of BMI, our results showed that over half of the students (51.1%) were underweight (Fig. 2). The percentage of overweight and obese students was 10.3%. There was a significant difference in the prevalence of flatfoot among the underweight (13.9%), normal weight (16.1%), overweight (26.9%), and obese (30.8%) children (chi-square = 14.32; p = 0.002) (Table 3). This finding suggests that as weight increased, the percentage of those with flatfoot also increased.

Multiple regression analysis of flatfoot and demographic variables is shown in Table 4. A combination of three demographic variables was a predictor for flatfoot: being younger (β = −0.228), being male (β = −0.062), and being overweight (β = 0.246). Along

| Table 1 | Distribution of foot stance in our series. |
|---|---|---|---|
| Cumulative percent | Percent | Frequency | Foot |
| 83.9 | 83.9 | 971 | Normal |
| 95.5 | 11.6 | 135 | Ff1 |
| 99.9 | 4.4 | 51 | Ff2 |
| 100.0 | 0.1 | 1 | Ff3 |
| 100.0 | 1158 | Total |

Ff1: Grade 1 flatfoot, Ff2: Grade 2 flatfoot, Ff3: Grade 3 flatfoot.

| Table 2 | Distribution of foot stance among different age groups. |
|---|---|---|---|---|
| Age group | Total |
|   | 1 | 2 | 3 |
| Foot | Normal | Frequency 329 266 376 | 971 |
|   | Percentage 33.9% 27.4% 38.7% | 100.0% |
| Ff1 | Frequency 68 28 39 | 135 |
|   | Percentage 50.4% 20.7% 28.9% | 100.0% |
| Ff2 | Frequency 24 14 13 | 51 |
|   | Percentage 47.1% 27.5% 25.5% | 100.0% |
| Ff3 | Frequency 0 1 0 | 1 |
|   | Percentage 0.0% 100.0% 0.0% | 100.0% |
| Total | Frequency 421 309 428 | 1158 |
|   | Percentage 36.4% 26.7% 37.0% | 100.0% |

Ff1: Grade 1 flatfoot, Ff2: Grade 2 flatfoot, Ff3: Grade 3 flatfoot.
with the age and gender, BMI was a predictor of flatfoot (β = 0.195). The variables explained 59% of the variance.

Discussion

The present study was conducted to study the prevalence of flatfoot among school students and also to investigate the relationship between BMI and flatfoot. The prevalence of flatfoot in our series was 16.1%. Similar to our results, the incidence of this deformity in another study was reported as 16.4%.12 Other studies demonstrate the ranging prevalence of flatfoot between 2.7% and 44%.11,12 Our findings indicate that the prevalence of flatfoot among girls and boys as 14.5% and 17.5%, respectively, with no significant difference. Close to our findings, Bordin et al reported that the rate of flatfoot in their series of school students as 18% in boys and 14.6% in girls.13 In other studies, however, the prevalence of flatfoot in girls is higher than that in boys.10,17 A higher incidence of flatfoot in girls is expected due to smaller bones and less bulky muscles. In addition, girls wear closed-toe shoes that are detrimental to the development of the arches of the foot.10

In our opinion, these differences could be due to several factors, which may not be fully studied earlier, such as, absence of a common or standardized assessment, inadequate experience, gender, age range, obesity, genu valgum, femoral and tibial torsion abnormality, ligament laxity (flexible flatfoot), footwear, race and heredity, activity, and even living in rural or urban areas.15

Kamali et al assessed the prevalence of flatfoot among their series with the method of differential pressure footprint mat of Harris and Beath.20 The results were incredible with a higher prevalence of 11.8% in girls. This shows us how essential it is to use a standardized scale in evaluation of the flatfoot to reach a valid result.

Similar to the results of other studies, we also detected a decreasing trend in the prevalence of childhood flatfoot with increasing age. This finding confirms the opinion of the authors that flatfoot in younger children could be a physiological phenomenon which could be corrected with time through muscle and tissue development.11,20

The increase in the prevalence of childhood obesity is one of the most serious health challenges across the globe. This is a payoff for sedentary lifestyle and altered nutrition habits. Our study showed that the prevalence of increased BMI is 10.3% among the school children from north of Iran, contrary to those from south of Iran which has a reported prevalence of 15%.21 This discrepancy even in the same country shows that the condition is related to many factors including lifestyle and culture. A positive correlation between increased BMI and flatfoot was found in this study. Similarly, Chen et al reported a strong significance between flatfoot and increased BMI in children.22 In another study, however, no significant relationship was found between BMI and flatfoot.23 But from our point of view, bearing extra weight on the lower limbs would increase the BMI and other factors.

In conclusion, schools are the right place to evaluate obesity and flatfoot among children. Obesity in younger age could be a cause of flatfoot and decreasing the prevalence of flatfoot can be possible by controlling the BMI and other factors.

Conflict of interests

No conflict of interests declared.

Table 3

Relationship between BMI and foot stance in our series.

| Foot stance    | Underweight | Ff1 | Ff2 | Ff3 | Total |
|----------------|-------------|-----|-----|-----|-------|
| BMI            |             |     |     |     |       |
| Underweight    | 510         | 62  | 20  | 0   | 592   |
| Normal         | 375         | 50  | 22  | 0   | 447   |
| Overweight     | 68          | 19  | 5   | 1   | 93    |
| Obese          | 18          | 4   | 0   | 0   | 26    |

Ff1: Grade 1 flatfoot, Ff2: Grade 2 flatfoot, Ff3: Grade 3 flatfoot.

Fig. 2. Distribution of BMI (body mass index) in sample.

Table 4

Multiple regression analysis of foot stance and demographic variables.

| Criterion | Significant predictor | β regression coefficient | p   |
|-----------|-----------------------|--------------------------|-----|
| Foot stance | Age                   | 0.228                    | 0.001|
|            | Gender                | -0.052                   | 0.034|
|            | Weight                | 0.246                    | 0.021|
|            | BMI                   | 0.195                    | 0.001|

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