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Epidemiological Characteristics and Influencing Factors of Flatfoot among Primary and Middle School Students in Inner Mongolia

Zhigang Bai, Chenggang Qiao*, Jinquan Bao, Jiping Nie, Yuxing Qin, Zilong Li, Tianqi Huo, Bo Li

The Second Affiliated Hospital of Inner Mongolia Medical University, Hohhot 014010, Inner Mongolia, China

**Author to whom correspondence should be addressed.*

A**bstract:** *Objective*: To analyze the epidemiological characteristics and influencing factors of flatfoot among primary and middle school students in Inner Mongolia. *Methods*: A survey was conducted among 2,800 primary and middle school students in Inner Mongolia. The foot arch and plantar pressure of the subjects were measured using the footprint method and the FootcanUSB plantar pressure testing system, respectively. The incidence of flatfoot among primary and middle school students was statistically analyzed, and regression analysis was used to analyze the influencing factors of flatfoot occurrence. *Results*: Among the 2,800 students, 867 cases of flatfoot were detected, with a detection rate of 30.95%. The proportions of mild, moderate, and severe flatfoot were 21.12%, 46.23%, and 31.62%, respectively. The detection rates of flatfoot among males and females were 20.04% and 10.93%, respectively, with the male detection rate significantly higher than that of females ($P < 0.05$). The detection rates of flatfoot among students aged 7 to 14 years old were 49.42%, 42.18%, 40.34%, 35.78%, 28.49%, 23.33%, 15.79%, and 11.95%, respectively. The detection rates of flatfoot varied among students of different ages, and the detection rate gradually decreased with increasing age. Weight, household registration, extracurricular activities, and shoe type were all influencing factors of flatfoot occurrence among primary and middle school students, in addition to BMI and physical exercise ($P < 0.05$). The risk and protective factors for flatfoot occurrence among primary and middle school students were BMI and physical exercise, respectively ($P < 0.05$). *Conclusion*: The incidence of flatfoot is relatively high among primary and middle school students in Inner Mongolia. Relevant factors for the occurrence of flatfoot include weight, household registration, and physical exercise. To reduce the occurrence of flatfoot, it is recommended to control weight and engage in regular physical exercise.

Keywords: Flatfoot; Students; Incidence; Influencing factors

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1. Introduction

As a common orthopedic foot deformity, flatfoot mostly refers to the collapse or absence of the medial longitudinal

arch of the foot. Its occurrence can affect the overall gait and lower extremity force, which can not only cause muscle pain but also result in abnormal gait [1]. The occurrence of flatfoot is not only related to congenital factors such as laxity of the plantar ligaments or tendons and equinovarus deformity, but also to the insufficient development of tendon strength caused by lack of physical exercise [2]. Flatfoot can cause abnormal biomechanical parameters, which can not only cause pain and lead to mechanical imbalance but also result in foot dysfunction and lead to overuse injuries of the lower extremities. The incidence of flatfoot is relatively high among young children and adolescents. Scientific examination and intervention can correct the gait of patients with flatfoot and prevent related foot diseases [3]. Based on this, this study selected 2,800 primary and middle school students in Inner Mongolia for investigation to analyze the epidemiological characteristics and influencing factors of flatfoot among primary and middle school students in Inner Mongolia, providing a basis for the prevention and treatment of flatfoot.

2. Subjects and methods

2.1. Research subjects

A survey was conducted among 2,800 primary and middle school students in Inner Mongolia. The students were randomly selected with a 1:1 ratio of males to females, aged between 7 and 14 years old. Students with a history of surgery, trauma, or severe diseases were excluded.

2.2. Methods

2.2.1. Survey questionnaire

The survey questionnaire included basic information, as well as questions about physical exercise, study and extracurricular activity time, shoe type, eating habits, and household registration type. Body mass index (BMI) was also calculated.

2.2.2. Arch and plantar pressure testing

The foot arch and plantar pressure of the subjects were measured using the footprint method and the FootcanUSB plantar pressure testing system, respectively. For foot arch measurement, students were asked to step on a piece of paper soaked in 10% potassium ferrocyanide solution and then dried, after stepping on a gauze soaked in 10% ferric chloride solution. This would leave a blue-black footprint on the paper, and the area of contact between the student's feet and the ground was calculated. For plantar pressure testing, students were asked to walk barefoot on a force plate placed on a flat surface. After walking at a normal pace three times, the collected data was analyzed.

2.3. Statistical methods

SPSS 22.0 statistical software was used for analysis. Measurement data and count data (relative numbers) were tested using *t* and chi-square tests, respectively. Logistic regression analysis was used for multifactor analysis. A *P*-value less than 0.05 was considered statistically significant.

3. Results

3.1. Detection rate of flatfoot and related factors

Among the 2,800 students, 867 cases of flatfoot were detected, with a detection rate of 30.95%. Among them, there

were 185, 405, and 277 cases of mild, moderate, and severe flatfoot, accounting for 21.12%, 46.23%, and 31.62%, respectively. The detection rates of flatfoot among males and females were 20.04% and 10.93%, respectively, with the male detection rate significantly higher than that of females ($P < 0.05$).

3.2. Detection rate of flatfoot

The detection rates of flatfoot among students aged 7 to 14 years old were 49.42%, 42.18%, 40.34%, 35.78%, 28.49%, 23.33%, 15.79%, and 11.95%, respectively. The detection rates varied among students of different ages, and the detection rate gradually decreased with increasing age. See **Table 1** for details.

Table 1. Detection rate of flatfoot among students of different ages

Age (years)	Number of cases	Number of detected cases	Detection rate (%)
7	346	171	49.42
8	358	151	42.18
9	352	142	40.34
10	341	122	35.78
11	358	102	28.49
12	360	84	23.33
13	342	54	15.79
14	343	41	11.95

3.3. Single-factor analysis of flatfoot among primary and middle school students

Weight, household registration, extracurricular activities, and shoe type were all influencing factors for the occurrence of flatfoot among primary and middle school students. Additionally, BMI and physical exercise were also included ($P < 0.05$). See **Tables 2** and **3** for details.

Table 2. Assignment of categorical variables

Variables	Assignment
Gender	Male = 1, Female = 2
Household registration type	Rural = 1, Urban = 2
Physical exercise	None = 1, Occasional = 2, Regular = 3
Study time (per day)	< 6 = 1, 6–8h = 2, > 8h = 3
Extracurricular activity time	< 2 = 1, 2–4h = 2, > 4h = 3
Eating habits	Poor = 1, Good = 2
Type of shoes worn	Appropriate shoes = 1, Inappropriate shoes = 2
BMI	Underweight = 1, Overweight = 2, Normal = 3

Table 3. Single-factor analysis of influencing factors for flatfoot among primary and middle school students

Variables	*β*	SE	Wold	*P*	OR	95% CI
Age	0.152	0.953	1.652	0.103	1.162	0.892–1.452
Gender	-0.151	0.532	0.024	0.783	0.895	0.457–1.844
Height	0.107	0.881	0.038	0.863	1.002	0.864–1.046
Weight	0.326	0.231	16.242	0.000	1.253	1.143–1.642
BMI	0.564	0.363	19.024	0.000	1.674	1.342–2.153
Household registration type	0.806	0.214	5.633	0.023	2.235	1.113–4.634
Physical exercise	-0.786	0.764	4.532	0.048	0.452	0.212–0.956
Study time	0.542	0.412	2.173	0.076	1.673	0.864–3.324
Extracurricular activity time	-0.673	0.684	8.533	0.043	0.467	0.231–0.986
Eating habits	-0.563	0.401	3.165	0.063	0.487	0.231–1.223
Type of shoes worn	0.476	0.613	4.756	0.031	1.542	1.021–2.673

3.4. Multifactor analysis of influencing factors for flatfoot among primary and middle school students

The risk and protective factors for the occurrence of flatfoot among primary and middle school students were BMI and physical exercise, respectively ($P < 0.05$). See **Table 4** for the results of the multifactor analysis.

Table 4. Multifactor analysis of influencing factors for flatfoot among primary and middle school students

Variables	*β*	SE	Wold	*P*	OR	95% CI
BMI	1.574	0.874	17.434	0.000	1.785	1.587–2.431
Physical exercise	-0.689	0.518	21.245	0.000	0.147	0.021–0.342

4. Discussion

Flatfoot is a foot deformity disease characterized by a low and flat foot arch, hindfoot valgus, and forefoot abduction. The occurrence of flatfoot in children is not only related to tarsal joint problems but also associated with neuromuscular diseases [4]. The medial arch of the foot bears greater pressure due to the abnormal biomechanical line caused by flatfoot. If this condition persists for a long time, it can not only damage the foot but also cause lower extremity injuries. For children with flexible flatfoot, they are usually asymptomatic, and no intervention measures may be necessary. However, some scholars believe that early intervention measures should be taken for children with flatfoot to avoid later foot complications and potential impacts on adulthood [5]. Flatfoot not only affects foot function but also impacts the quality of life of patients. The results of this study showed that among 2,800 students in Inner Mongolia, 867 cases of flatfoot were detected, with a detection rate of 30.95%. The detection rate in males was significantly higher than in females, which is consistent with the research results of Liu *et al.* [6]. Among them, there were 185, 405, and 277 cases of mild, moderate, and severe flatfoot, accounting for 21.12%, 46.23%, and 31.62%, respectively. This indicates that the incidence of flatfoot among primary and middle school students in Inner Mongolia is relatively high, with gender differences, and the proportion of moderate and severe flatfoot is relatively high.

Research has shown that the occurrence of flatfoot is related to age [2]. Childhood is an important period for the development of the foot arch. Due to the low and flat foot arch, the human body is in an abnormal biomechanical environment for a long time, and the plantar pressure cannot be evenly distributed, which can cause foot lesions and lower extremity complications such as medial tibial stress syndrome. The results of this study showed that the detection rates of flatfoot among students aged 7 to 14 years old were 49.42%, 42.18%, 40.34%, 35.78%, 28.49%, 23.33%, 15.79%, and 11.95%, respectively. The detection rates of flatfoot vary among students of different ages, and the detection rate gradually decreases with age, which is consistent with the research results of Zhang *et al.* [7]. The risk and protective factors for flatfoot among primary and middle school students are BMI and physical exercise, respectively. Plantar pressure can increase with increasing BMI or body weight, which can affect the foot arch and lead to flatfoot. Therefore, it is necessary to pay attention to students' diet and exercise, control their weight within a normal range, and prevent the occurrence of flatfoot [8]. Physical exercise plays a good role in preventing and improving flatfoot. It can not only enhance ligament strength but also improve foot muscle strength, enhance the ability to maintain the foot arch structure, prevent foot arch collapse or disappearance, and reduce the occurrence of flatfoot [9].

5. Conclusion

In summary, the prevalence of flatfoot among primary and middle school students in Inner Mongolia is relatively high, and the situation is relatively serious. Relevant factors for the occurrence of flatfoot among primary and middle school students include weight, physical exercise, etc. Therefore, it is necessary to pay attention to students' diet and exercise, control their weight within a normal range, and strengthen physical exercise to reduce the occurrence of flatfoot.

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Disclosure statement

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