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Original Article

Flat Foot and Associated Factors among University Students Aged 18-25 Years: A University-Based Study

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ABSTRACT

Background: In various human postural studies, foot is considered to be a rigid body. The flat foot, also referred to as the acquired disorder of the flat foot, results from the subsidence of the arches of the feet. Usually, in an upright position, the middle margin of the sole of the foot does not touch the ground. The condition of flatfoot can affect the healthy lifestyle and the weight management for an individual. But the burden of the flat foot in young adults is unknown. **Aim:** The objective of this study is to identify the prevalence of flat foot and investigate its associated factors among university students aged 18-25. **Materials and Methods:** A university cross-sectional study was conducted on students between the ages of 18 and 25. The data collection consisted in physical measurements, measurements based on the footprint while fully bearing the weight to analyze the structure of the medial foot arch using the Staheli arch index and their footwear types. Data were analysed through chi-square test and multivariate logistic regression model. **Results:** In total, 875 university students participated. The overall incidence rate for the flat foot was found to be 29.37% for entire study sample, accounting 31.79%, 15% and 26.54% for Chinese, Tanzanian, and Indian students respectively. Uni-variate analysis found that gender and the shoe types often worn were not the influencing factors of flat foot, but multivariate regression analysis showed that age, BMI, nationality and shoe type were the influencing factors of flat foot. **Conclusion:** Results from this study showed overall prevalence of flatfoot close to 30% and a negative correlation between age and incidence of flat foot for college students aged 18-25 years.

Keywords: Flatfoot, Staheli arch index, BMI, Footwear, Nationality.

INTRODUCTION

The development of the lower extremity and anatomical changes to the foot result in a strong and stable posture that distinguishes humans from other animal species.[1] One of the most notable changes in human evolution has been the anatomical and functional evolution and development of the human foot.[2] The human foot is a sophisticated mechanism that allows for orthograde bipedal posture and movement. The feet of bipeds bear the entire body's weight and help to balance the body under shifting postural and environmental settings.[3] It's the only portion of the body that touches the ground on a regular basis.[4] The architecture of the foot, which is formed of foot bones, the ligaments and tendons allow the foot to support the weight of the body in a straight and balanced position with the least possible weight, helps to permit this advanced modification and function. The Median Longitudinal Arch, Lateral Longitudinal Arch, and Transverse Arch all exist in the foot.[5,6] These arches aid in the distribution of bodily weight in a proportionate manner.

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The structure and dynamic action of the foot arches are essential for various functions of foot such as weight transmission, shock absorption, propulsion of body during locomotion.[7,8] Among the arches of foot Medial longitudinal arch is higher than the Lateral longitudinal arch and it flattens during weight bearing activity to variable degrees.[9,10] A healthy foot is essential to proper posture and walking.

Flatfoot or planus pes can be a therapeutic condition characterized by lack of appearance or lowered average longitudinal curvature, with an Osseo-ligamentous misalignment.[11] The anatomical appearances of smoothing or bringing down of average foot-arch are ligament laxity, equine distortion, torsional deformity, vertical embankment and tarsal amalgamation, caused by multifactor factors such as overweight, weight, sort of shoes, fragile muscles which bolster the curve, foot damage, and intrinsic or congenital anomalies.[12-15]

In the presence of the flatfoot, there's a bio-mechanical alteration of the body's centre of gravity and kinetic chain, that increases stretching on the articular structures of the spine, hip, knee and lower leg resulting in the stride and postural absconds in all ages groups.[16] A variety in foot pose plays an imperative part in inclination to harm.[17] The wounds not as it were depend on the sort of foot but too on other variables just like the age of the individual, the tallness, weight, BMI of the people, and sort of shoes.[15,18,19] As people become older, the aetiology of flat feet switches from normal physiological substance to a distortion produced by fundamental alterations in foot life systems which, if left untreated, can create devastating side walk difficulties.[20] Flat arches can expose the affected person to excessive stress and a faulty mechanism which that causes pain and discomfort. This makes it an essential aspect to life quality and the extent of difficulty in activities of daily living. Various literature regarding the various foot types in children have been reported[20-22] but literature still lacks the data about young adults. It is being stated that anthropometric measures such as height, weight, and BMI are all age dependent, which make these factor to be examined with different age groups so as to ascertain whether these factors which affect in childhood persist in adulthood.

As a result, we believe that a cross-sectional survey of university students aged 18 to 25 years old; we can get a close approximation of prevalence by applying the standardized, recommended technique of foot posture assessment (Staheli arch index). We are certain that the methodology utilized in this study, as well as the findings, will aid aspiring health professionals in recognizing flatfoot prevalence, related variables, and intervening as needed. The purpose of this study was to use Staheli plantar arch index (SPAI) of footprints to determine the prevalence of flatfoot among university students aged 18 to 25 years old and to discover features associated to flatfoot.

MATERIALS AND METHODS

Study design, background and population

A cross-sectional study was undertaken at Dali University, Yunnan, China. According to the Dali University records there are in total 17,660 undergraduate students, with 1,113 international students mainly from India, Tanzania, Pakistan, Nepal, Cambodia, Laos and Thailand. The target population includes all university students between 18-25 years of age of both genders at Dali University.

All study participants were directed to the goals and purpose of the study before they took part in the study. The Informed consent was received from the participants. Participant's participation was discretionary. Confidentiality and anonymity were outlined.

Sample size and sampling technique

All university students studying in Dali with consent and able to ambulate freely were included as population source. In the sampling, students with known or obvious disorders of lower limb, lower extremity or deformation of the foot, weakness or paralysis of the lower limb, recent injuries of the lower limb, and recent lower extremity surgical procedures that would affect the accuracy of foot outcomes were excluded from the study.

Due to the lack of data on the prevalence rate of flat foot in students aged 18-25, a pre-survey was conducted to generate the necessary reference for estimating study sample size.[23] In the pre-survey, 3 data collectors surveyed and gathered the data for potential associated factors and footprint measurement of 50 postgraduate Chinese university students belonging to the batch 2020 in the School of Public Health at Dali University, and the results have shown that only 5 among 50 students had flat feet; i.e., the prevalence rate according to the pre-survey was estimated as 10%. The sample size was estimated according to formula 1 with δ and α value to be 0.03 and 0.05 respectively.[24] There were 16,487 Chinese students in total and 1,113 international students. It turned out that the sample size for Chinese students was 376 and that for international students was 230.

For Chinese students scattered in 14 colleges, cluster sampling was carried out. One class was selected form each major from every college. Due to a larger sampling error compared to complete random sampling, thus 1.5 times of sample size calculated from formula-1 was adopted as refined sample size of 564.[24] Further considering the compliance rate of participants, we expanded the sample size by 1.1 times in close approximation to 620. Each class includes 35~55 Chinese students, therefore a total of 618 students were recruited.

When taken into consideration the absence of some international students due to COVID-19 pandemic, the sample size was enlarged more (1.2 times) and the final sample size should be approximate to 276.[24] There are six colleges which include international students. Complete random sampling was carried out for international students, henceforth, sampling was done according to the sample size proportion among all international students (276/1113 $\approx$ 25%), and a total of 281 students were recruited (Figure 1).

$$n=(z_{\alpha}^{2}\pi(1-\pi)/\ \delta^{2})/(1+((z_{\alpha}^{2}\pi(1-\pi)/\ \delta^{2})-1)/N)$$

Formula 1[25]

Data compilation and procedure

A structured questionnaire was used to document the socio-demographic data which included age, gender, weight, height, country and 'shoe types often worn. Computation of participant's weight (kg) was done using a digital weighing scale, and height was measured using a stadiometer. The BMI (Body Mass Index)

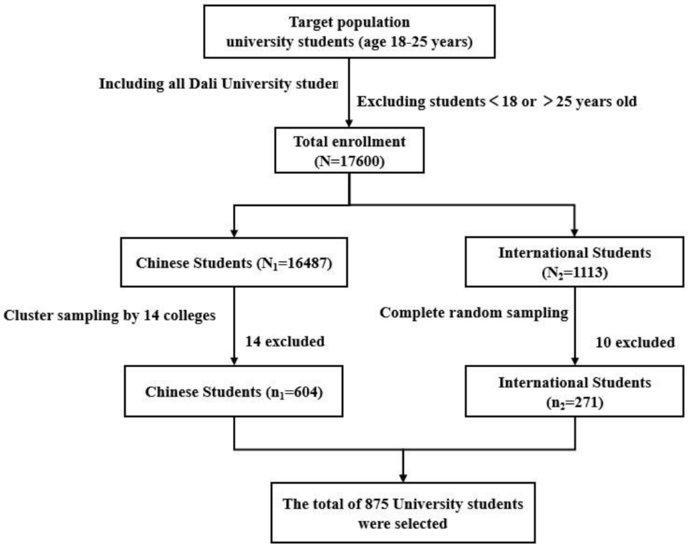

Figure 1: Flowchart for sampling procedure.

Figure 2: Measurement of Staheli's plantar arch index on footprint in (a) Normal foot (b) Flat foot.
"A" denotes the width of the narrowest part of mid-foot; "B" denotes the width of the hind-foot.

was computed in accordance with the following formula: BMI = Weight (kg) / [height (m)] ^{2}. BMI values, in addition to treated as continuous data, were also classified into four groups based on World Health Organization (WHO) criteria; <18.5 kg/m^2, 18.5~23.9 kg/m^2, 24~27.9 kg/m^2, and ≥28 kg/m^2, which represented low weight, normal weight, overweight and obesity respectively. The feet were carefully cleaned and dried and the participants in the seated position were asked to dip the feet into the ink tray. The participants were then asked to remove the foot from the tray and get up to firmly imprint the feet on the sheet on the wooden platform with approximately 50% weight-bearing.

The SPAI was then calculated using the participants footprint for each foot, following the labelling the sheet with the unique identification number of the participant's data and the foot side (right and left). With the aid of a pencil, a tangential line was drawn tangential at the medial edge of the forefoot and rear-foot; the midpoint of both the lines was marked.[25,26] The narrowest printed part of the mid-foot changed into identified each visually and using a ruler, the perpendicular distance (line A) representing the width the narrowest a part of mid-foot is marked. Whereas, second perpendicular line (line B) was drawn which represented the width of hind-foot, and line A and line B measurement were noted (Figure 2).

The SPAI was then calculated through the Staheli arch index approach with the aid of dividing the values of line A by that of line B (AI= A/B) and the ratio between those widths is known as Staheli's Arch Index (AI).[26,27] Participant with Staheli Arch Index >1.5 was taken into consideration to have flatfoot.[27]

Intensive training for data collectors

Before the start of data collection, 3-day extensive training was given to the 5 data collectors on the procedure to be followed for collection of data by the two main investigators. After intensive training a pre-test was conducted among 10 participants to evaluate the inter-observer's consistency. The Cronbach's α value was found to be 0.999, indicating a good inter-observer's consistency. The process of data collection was supervised by the two chief investigators on a day by day basis to make certain its standardization, plenitude, precision, and lucidity.

RESULTS

Participant's characteristics

A total of 875 students participated, including 604 Chinese students (69.03%), 60 Tanzanian students (6.86%) and 211 Indian students (24.11%). Among the Chinese students, 8 students asked to leave the study because of some health issue and 6 students have shown difficulty to stand due to lower limb trauma and low back pain. Due to the COVID 19 pandemic, 10 international students were not in University and were still in their home country for the period of data collection, therefore a total of 271 international students were surveyed.

The participants included a total of 439 males and 436 females. These include 304 (50.3%) males and 300 (49.67%) females Chinese participants; 20 (33.33%) and 115 (54.50%) males along with 40 (66.67%) and 96 (45.50%) females participants from Tanzania and India respectively. The gender ratios of Chinese and Indian students were statistically significantly different from that of Tanzanian students (Figure 3).

The average age of participants was 21.05 years, the average height was 164.68 cm, and average weight was 58.48 kg with the average body mass index to be 21.49 kg /m² (Table 1).

Flatfoot prevalence and its associated factors

There were 257 participants who have shown flatfeet with at least in one of their feet accounting for a total prevalence rate of 29.37%. Except for gender and shoes types, all other factors including region, nationality, and BMI were statistically significantly related to the prevalence of flatfoot (Table 1). Furthermore, there were statistically significant difference in the prevalence of flatfoot for males in between Tanzania and China and for females among Tanzania and India (Figure 4).

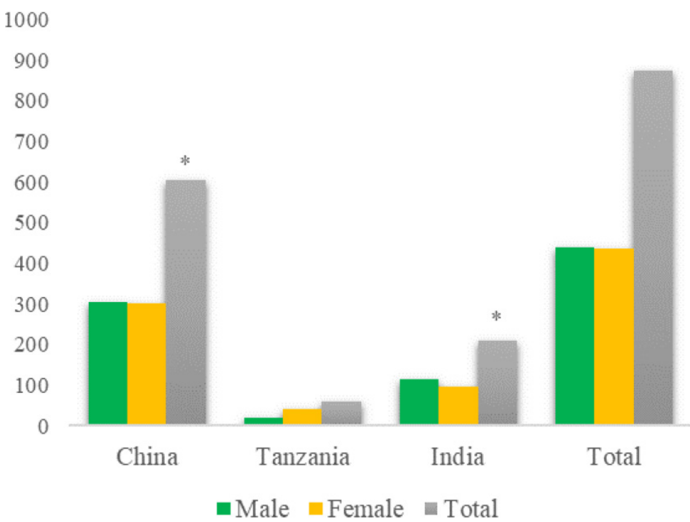

Figure 3: Gender distribution among different Nationalities.
*: Compared with the gender ratio of Tanzanian participants p<0.05.

As shown in Table 2, Multivariate regression analysis showed that age, BMI, nationality and shoe type were the influencing factors of flat foot. Multivariate analysis showed that the incidence of flat foot reduced with age after controlling for other influencing factors; and the higher the BMI, the higher the risk of flat foot. Nationality is also one of the important factors affecting the occurrence of flat feet. The incidence of flat feet is lower among Tanzanian students than among Chinese students. Uni-variate analysis showed that common shoe type was not one of the factors affecting the impression of flat foot. To control the influence of the potential confounding factors, multivariate logistic regression analysis was modeled. It was found that college students wearing high heels were more likely to develop flat foot disease than those wearing flat shoes (Table 2 and Figure 5).

DISCUSSION

According to the statistical data of the large-scale foot measurement in China, which was completed in 2003, the prevalence of flat feet among people aged 12-30 increased by 20% when compared with the results of the first ever measurement

Table 1: Flatfoot related influencing factors and distribution variables of Chinese and foreign students (n=875).

Variables n (%)		Total number of samples	Flat foot *n* (%)		$\chi 2$	*p*
		None	Present			
Total		**875(100)**	**618(70.63)**	**257(29.37)**	**-**	**-**
Age	18	14	10	4	14.151	0.049*
	19	110	67	43		
	20	257	170	87		
	21	216	162	54		
	22	135	102	33		
	23	57	40	17		
	24	50	37	13		
	25	36	30	6		
Gender	Male	439(50.17)	304(69.25)	135(30.75)	0.809	0.205
	Female	436(49.83)	314(72.02)	122(27.98)		
BMI(Grades)	Below average	137(15.66)	109(79.56)	28(20.44)	8.434	0.038*
	Normal	516(58.97)	363(70.35)	153(29.65)		
	Overweight	110(12.57)	75(68.18)	35(31.82)		
	Obese	112(12.80)	71(63.39)	41(36.61)		
Nationality	China	604(69.03)	412(68.21)	192(31.79)	8.489	0.014*
	Tanzania	60(6.86)	51(85.00)	9(15.00)		
	India	211(24.11)	155(73.46)	56(26.54)		
Shoe types often worn	Closed shoes with flat heel	472(53.94)	331(70.13)	141(29.87)	5.057	0.168
	High heel	112(12.80)	85(75.89)	27(24.11)		
	High heel close shoes	54(6.17)	32(59.26)	22(40.74)		
	Flat heel	237(27.09)	170(71.73)	67(28.27)		

*：p<0.05.

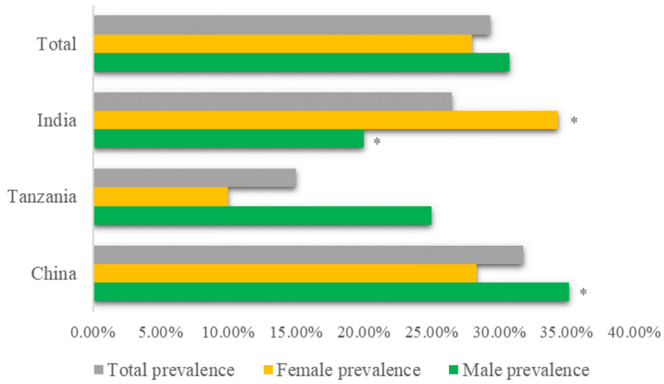

Figure 4: Prevalence of flatfoot by nationalities and gender.
*: Compared with the prevalence of flatfoot in Tanzanian students, p<0.05.

Table 2: Binary logistic regression of flatfoot related influencing factors of Chinese and Foreign students (n=875).

Factors	*β*	*Wald*	*P*	*OR*	95%*CI*
Age	-0.158	8.596	0.003*	0.854	0.777 ~ 0.958
BMI (Ref.= Below average)	-	10.047	0.007*	-	-
Normal	0.225	1.001	0.317	1.252	0.806 ~ 1.943
Overweight	0.735	9.750	0.002*	2.085	1.315 ~ 3.307
Obese	0.297	1.677	0.195	1.346	0.859 ~ 2.109
Nationality (Ref.= Chinese)	-	7.653	0.022*	-	-
Indian	-0.396	2.350	0.125	0.673	0.406 ~ 1.116
Tanzanian	-1.126	7.235	0.007*	0.324	0.143 ~ 0.737
Gender (Ref.= Female)					
Male	-0.040	0.002	0.799	0.961	0.709 ~ 1.303
Shoe types often worn(Ref.= Closed high-heel shoes)	-	5.029	0.170	-	-
High heeled Sandal	-0.508	1.816	0.178	0.602	0.288 ~ 1.259
Closed shoes with flat sole	-0.601	3.985	0.046*	0.548	0.304 ~ 0.989
Flat sandals	-0.279	0.659	0.417	0.756	0.385 ~ 1.484
Constant	2.918	6.093	0.014	18.499	-

*:$p<0.05$.

done during 1960s.[28] Although the prevalence rate of flatfoot in China was suggested to be increasing, the concrete value was not available. A pre-survey was therefore driven to estimate the prevalence of flatfoot amid the target population, and thus the sample size was generated accordingly. However higher prevalence rate was found in formal survey. This could be as the result of a higher representativeness and accuracy in terms of the application of random sampling methods as well as larger sample size. Meanwhile, gender being one of the studied factors, the proportion of it was not standardized for sample size calculation.

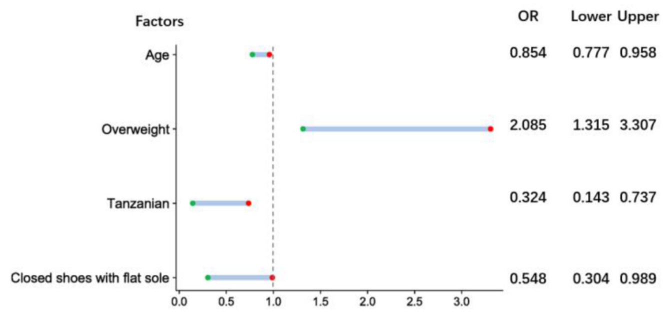

Figure 5: Forest plot of OR values.

This cross-sectional survey has found that the overall prevalence of flat feet among college students aged 18-25 was 29.37%, which was at a high level and consistent with the increasing trend as reported in literature.[29] Flat foot is a condition that develops due to multiple causation factors. It was found that age, BMI, nationality and shoe type were all significant factors for flatfeet.

There is inconsistency in results related to pediatric population, showing increase as well as decrease in prevalence of flatfoot with increase in age.[29,30] Our study displayed a negative correlation between age and prevalence of flatfoot for college students aged 18-25 years.

In terms on BMI being the risk factor leading to flatfoot, the prevalence as per the results have shown overweight being the one of the risk factors contributing to development of flatfoot, compared to underweight. This is also supported by studies which state that overweight BMI impacts on foot posture alignment and body stability, also overweight girls showed flatter feet than normal weight ones.[31,32]

In comparison with Chinese students, the students from Tanzania have shown less prevalence for flatfoot, whereas those from India have no significant differences. The probable reason could be the athletic behavior found among the African students but this need to be investigated in future studies.

Uni-variate analysis found that gender and the shoe types often worn were not the influencing factors of flat foot, but in multivariate analysis, the shoe types often worn was found to be one of it, so it is reasonable to suspect that gender is the confounding bias of the shoes types often worn.

Although we have targeted the population of university students aged between 18-25 years, we did not include the students with any condition affecting the lower extremity, therefore the result generalizability would be confined to a certain extend due to the selection bias.

CONCLUSION

In conclusion based on our cross-sectional study results, we have found the prevalence of flatfoot among college students to be close to 30%, which was unexpectedly higher than what we thought through our pilot study showing a prevalence rate of around 10%. Also, we are not able to find the incidence rate and its actual causes leading to flatfoot. Therefore, we would like to suggest further studies to identify the related risk factors and prevalence of flatfoot among the university students on a much larger scale or with follow-up study designs, so that based on the results prevention measures can be formulated and the health well-being to be approximated, which can prevent the structural and bio-mechanical faults in young adults.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

BMI: Body Mass Index; **SPAI:** Staheli Plantar Arch Index; **AI:** Arch Index.

SUMMARY

The aim of this study is to identify the prevalence of flat foot along with its associated factors in the university students aged 18-25. A structured questionnaire was used to file socio-demographic data which includes age, gender, weight, height, nationality and shoe type often worn. The SPAI become calculated by using Staheli arch index method. Any participant with Staheli Arch Index >1.5 was taken into consideration to have flatfoot. We have found the prevalence of flatfoot among college students approximately 30%. In comparison with Chinese students, the students from Tanzania have shown less prevalence for flatfoot, whereas those from India have no significant differences.

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