

Distribution of Foot Arch Type and Associated Symptoms in Medical Students at Faculty of Medicine, Thammasat University

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ABSTRACT

Objective: To determine the distribution of foot arch type, associated symptoms, and factors associated with moderate to severe pain

Materials and Methods: The cross-sectional study was collected data from 5th year medical students, Faculty of Medicine, Thammasat University in academic year 2020. The distribution of foot arch type used the footprint and classified by Harris imprint index (HII), Chippaux-Smirak index (CSI), Staheli index (SI). The associated symptoms were collected into pain and tightness. Pain score was rated by the volunteer using numeric rating scale (NRS) at each foot/leg separately.

Results: A total of ninety-eight medical students (196 feet) were recruited and analyzed. The distribution of foot arch type by HII, CSI and SI were 1) bilateral normal arched feet: 42.9%, 67.3%, 54.1% 2) bilateral pes planus: 8.2%, 12.2%, 21.4% 3) bilateral pes cavus: 25.5%, 6.1%, 5.1% 4) unilateral pes planus: 2%, 9.2%, 15.3% 5) unilateral pes cavus: 21.4%, 5.1%, 4.1%, respectively. The most commonly associated symptom of pes planus was midfoot pain (17%) while pes cavus and normal arched foot were hindfoot pain (22.4% and 17.3%). The factor associated with moderate to severe pain was BMI ≥ 23 kg/m² (OR = 3.23, 95%CI 1.63 - 6.41, p-value = 0.001).

Conclusion: Bilateral normal arched feet were mostly found. Midfoot pain in pes planus and hindfoot pain in pes cavus and normal arched foot were the greatest symptoms. BMI was a risk factor.

Keywords: Prevalence; flatfoot; talipes cavus; students medical; pain (Siriraj Med J 2024; 76: 346-352)

INTRODUCTION

The difference of foot arch such as pes planus (flatfoot) and pes cavus (high arched foot) cause ankle and foot pain, ankle deformity, walking instability, or frequent fall.¹ Additionally, some symptoms as knee pain, back pain, or leg muscle tightness might be found in patients with abnormal foot arch.² Pes planus is defined as a low medial longitudinal arch. The patient's symptoms showed a medial longitudinal arch collapse, prominent talar head along the medial border of the foot, hindfoot

valgus, forefoot varus, medial ankle swelling, or too many toes sign. The causes of pes planus are divided into congenital causes such as idiopathic, tarsal coalition, etc., or acquired causes such as posterior tibialis tendon dysfunction, arthritis, and trauma.^{1,3} Pes cavus is defined as a high medial longitudinal arch. The patient's symptoms showed an increased calcaneal pitch, hindfoot varus, tight plantar fascia, medial forefoot plantar flexion, metatarsus adductus, or peek a boo sign. The etiologies of pes cavus are 1) congenital as idiopathic cavus foot,

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2) neuromuscular disease such as Charcot-Marie-Tooth disease, poliomyelitis, and 3) trauma. Cavus foot is commonly caused by the idiopathic condition.³ The abnormality of foot arch might be found in one side or both sides.⁴ In Thailand, the prevalence of pes planus in 3rd year medical students at Chiang Mai University was 62%, divided into male 38% and female 24%.⁵ The treatments usually use a foot orthosis or to properly choose a type of shoe following the different foot arch type. The foot orthoses as a customized insole, medial arch support, or wedge, were frequently used in the clinic because it helped to reduce pain, decrease foot pressure, and improve balance.^{6,7}

Meanwhile, medical students had to study in the clinic level with extended standing or walking per a day. The foot and leg pain commonly found on study days might interfere with their learning. Foot deformity or other factors might cause their pain. Therefore, this study aims to determine the distribution of foot arch type by the footprint evaluation, associated symptoms, and the factors associated with moderate to severe pain in the 5th year medical students at Faculty of Medicine, Thammasat University.

MATERIALS AND METHODS

This cross-sectional study was approved by the Human Research Ethics Committee of Thammasat University (Medicine), MTU-EC-RM- 2-092/63, on 4 June 2020.

The 5th year medical students of academic year 2020 studied in the orthotic and prosthetic clinic, department of Physical Medicine and Rehabilitation, Thammasat University. Data was collected from ninety-eight 5th year medical students. Inclusion criteria was age ≥ 18 years but history of fracture and/or surgery in ankle and foot were excluded.

After screening and receiving volunteers' informed consent, the demographic data, the associated symptoms, and pain score were collected by the research assistant. The footprints were performed by the Harris mat footprint method. The Harris imprint index (HII), Chippaux-Smirak index (CSI), Staheli index (SI) were used because of ease-of-use, rapidity, and low tech in terms of instruments. Moreover, the accuracy of HII, CSI, and SI was fair in screening of pes planus and pes cavus.⁸ The HII, CSI and SI were conducted with computer-assisted program and measured by the rehabilitation physician. 1) The HII is a distance in centimeters (cm) measured between the origin of a horizontal line to its perpendicular contact point of a vertical landmark. The vertical axis (y-axis) halves the foot from the tip of the 2nd toe to the center of heel margin. The horizontal axis (x-axis) is drawn

at 90 degree to the vertical axis starting from the most medial side to the most lateral side of the arch. HII score is inferred from the relative distance from the origin of x-axis to the y-axis where the medial side of the y-axis has positive score, and the lateral side of the y-axis has negative score. HII score of -1, 0, 1 is classified as normal arched foot, whereas HII score of -4, -3, -2 and +2, +3, +4 is defined as pes cavus and pes planus respectively.⁸

2) The CSI is the ratio of the arch at its narrowest (line b) to the forefoot at its widest (line a). Line b and line a should be parallel. $CSI = b/a \times 100$. CSI for normal arched foot ranges from 25% to 45%. Pes cavus is defined as $CSI \leq 24\%$ and Pes planus is classified as $CSI \geq 46\%$.⁸

3) The SI is the ratio of the arch at its narrowest (line b) to the heel at its widest (line c). Line b and line c should be parallel. $SI = b/c$. SI for normal arched foot ranges from 0.5 to 0.7. $SI \leq 0.4$ is defined as pes cavus and $SI \geq 0.8$ is classified as pes planus.⁸ The associated symptoms divided into pain and tightness, which depended on the area. The areas of pain were forefoot, midfoot, hindfoot, ankle, leg, and back. The areas of tightness were sole, calf, and back. Pain score rated by the volunteer using numeric rating scale (NRS), which ranged from 0 of no pain to 10 of the most severe pain. They had to rate the pain NRS at each foot/leg separately. The pain NRS was classified into 4 groups as no pain (NRS =0), mild pain (NRS 1-3), moderate pain (NRS 4-6), and severe pain (NRS 7-10).⁹

Sample size calculation

The sample size was calculated from the prevalence of pes planus in a study of 3rd year medical students of Chiang Mai University, Thailand (62%) under 0.05 alpha error and 0.1 maximum tolerated error.⁵ Ninety-one was a sample size calculated, but the total number of 5th year medical students in the academic year 2020 was 98.

Statistical methods

Categorical data is presented as frequency and percentages. Continuous data is presented as mean, median, standard deviation and interquartile range, dependent on nature of data. The factors associated with moderate to severe pain were tested using univariate logistic regression. Odds ratio (OR) and 95% confidence interval (CI) were reported. A P-value of < 0.05 was considered statistically significant. The data was analyzed via STATA version 15.1.

RESULTS

A total of ninety-eight 5th year medical students of academic year 2020 (196 feet) were recruited and analyzed

in this study. (Fig 1) The average age was 22.9 ± 1.9 years. Female and male were 49% and 51%. Body mass index (BMI) was 22.3 ± 4.6 kg/m². On studying days, the duration of standing/walking was 8.1 ± 2.2 hour per day and flat shoes were frequently used (70.3%). The pain score was 4 (3,5) on right foot/leg and 4 (2,5) on left foot/leg. The pain score was mostly classified as moderate pain (right side 49.0% and left side 50%). (Table 1)

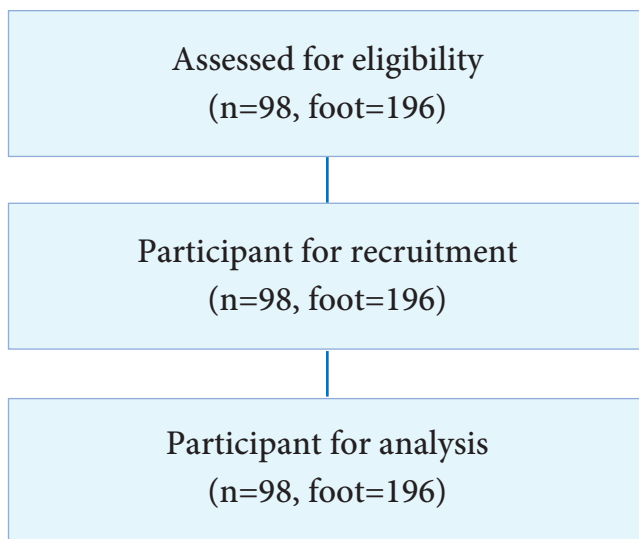


Fig 1. Flow of participants

The distribution of foot arch type by HII, CSI and SI are shown in fig 2. According to HII classification, bilateral normal arched foot was frequently founded (42.9%) following by bilateral pes cavus (25.5%), unilateral pes cavus (21.4%), bilateral pes planus (8.2%), and unilateral pes planus (2.0%), respectively. Meanwhile, CSI and SI classification showed bilateral normal arched foot was mostly founded (67.3% and 54.1%) following by bilateral pes planus (12.2% and 21.4%), unilateral pes planus (9.2% and 15.3%), bilateral pes cavus (6.1% and 5.1%), and unilateral pes cavus (5.1% and 4.1%), respectively.

Fig 3 shows the associated symptoms divided by the foot arch type. The associated symptoms of pes planus in HII, CSI, SI classifications and average from the three classifications were showed in fig 3a. The greatest symptoms of pes planus which averaged from HII, CSI and SI were midfoot pain (17.0%) followed by calf tightness (15.2%), and hindfoot pain (13.6%). Fig 3b shows the associated symptoms of pes cavus. The hindfoot pain (22.4%) was the mostly found in pes cavus averaged from HII, CSI and SI that followed by calf tightness (17.0%), and midfoot pain (15.1%). While the most associated symptoms of normal arched foot were hindfoot pain (17.3%) followed by back pain (17.0%), and leg pain (15.0%) showed in fig 3c.

The factors associated with moderate to severe pain (pain NRS ≥ 4) are shown in table 2. The BMI ≥ 23 kg/m² had a significant odds ratio (OR = 3.23, 95%CI 1.63 - 6.41, p-value = 0.001). In contrast, the OR of flat shoe had a statistical significance (OR = 0.49, 95%CI 0.24 - 0.98, p-value = 0.045).

DISCUSSION

The most prevalent foot arch type by three-footprint evaluation (HII, CSI, SI) in 5th year medical students was bilateral normal arched feet. The most common associated symptom of pes planus was midfoot pain, however, both pes cavus and normal arched foot were hindfoot pain. The risk factor associated with moderate to severe pain was BMI ≥ 23 kg/m² (overweight and obesity) by WHO Asian BMI classification.

This study showed the most prevalent foot arch type was bilateral normal arched feet (HII 42.9%, CSI 67.3%, SI 54.1%). However, the second and third level of foot arch type were different following each classification. The HII classification showed normal arched foot, followed by pes cavus, and pes planus, respectively. Similarly, the previous study in the medical students of Nobel Medical College, Nepal, showed normal arched foot followed by pes cavus and pes planus, respectively.¹⁰ In contrast with CSI and SI classification, this study showed that a normal arched foot was the most prevalent, then pes planus, and pes cavus, respectively. Likewise, the previous study in medical students of Mahatma Gandhi Medical College and Research Institute, India, and in the physiotherapy students of Isra Institute of rehabilitation sciences, Pakistan, showed the most prevalent foot arch type was normal arched foot followed by pes planus and pes cavus, respectively.^{11,12}

In Thailand, a study in 3rd year medical students of Chiang Mai University showed the prevalence of pes planus by CSI classification was bilateral sides (38%) and unilateral side (24%).⁵ In CSI classification, this study showed the distribution of pes planus was bilateral sides (12.2%) and unilateral side (9.2%). This may be because the cut-off point of CSI classification for pes planus diagnosis was different between the studies. However, the study in physiotherapy students of PDVVPF's, College of Physiotherapy, India, showed bilateral pes planus 11.25% by navicular drop test, arch index, and foot posture index.¹³ Despite the prevalence of bilateral pes planus being similar in this study, they used the footprint measurement differently.

Pes planus present with a flattening of the medial longitudinal arch of foot. The plantar pressure of pes planus was high at the medial midfoot area during walking.^{14,15}

TABLE 1. Demographic data

Variable	Frequency (%)
Age (year) (mean $\pm$ SD)	22.9 $\pm$ 1.9
Gender	
Female	48 (49.0)
Male	50 (51.0)
BMI (kg/m ²) (mean $\pm$ SD)	22.3 $\pm$ 4.6
Standing/ walking duration per day on studying day (mean $\pm$ SD)	8.1 $\pm$ 2.2
Shoe type on working day	
Flat shoe	71 (70.3)
Sneaker shoe	16 (15.8)
Sport shoe	13 (12.9)
Sandal	1 (1)
Pain score (median (P25, P75))	
Right foot/leg	4 (3,5)
Left foot/leg	4 (2,5)
Pain score classification	
Right foot/leg	
No pain (NRS = 0)	3 (3.1)
Mild (NRS 1-3)	36 (36.7)
Moderate (NRS 4-6)	48 (49.0)
Severe (NRS 7-10)	11 (11.2)
Left foot/leg	
No pain (NRS = 0)	5 (5.1)
Mild (NRS 1-3)	35 (35.7)
Moderate (NRS 4-6)	49 (50.0)
Severe (NRS 7-10)	9 (9.2)

Abbreviations: BMI = body mass index, NRS = numeric rating scale

Definitions of shoe type: flat shoe = a shoe with flat heels or no heels, sneaker shoe = a casual rubber-soled shoe, sport shoe = a shoe designed to be worn for sports, exercising, or recreational activity, sandal = an open-toed shoe consisting of a sole strapped to the foot
Definition of shoe type on working day was the same pair of shoes that the medical students always wear during study period.

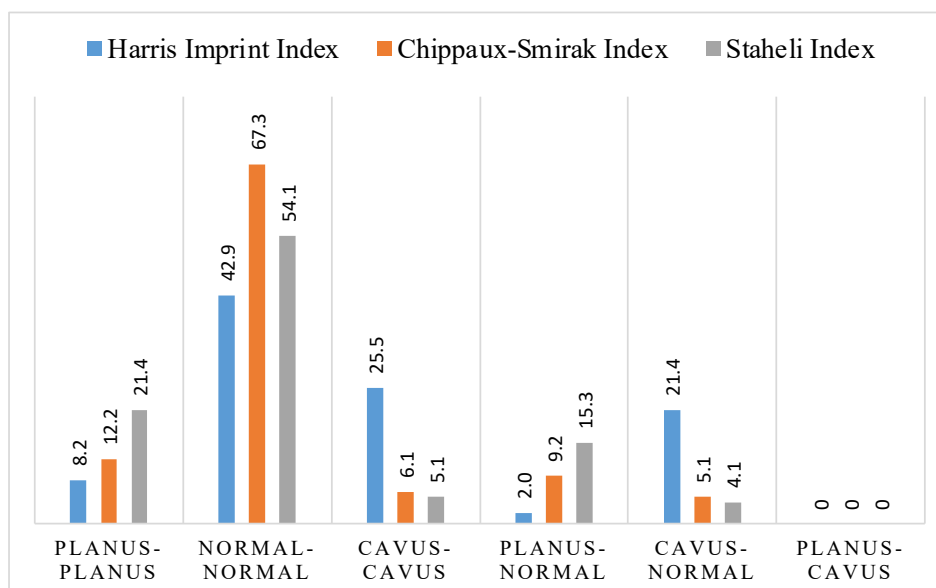


Fig 2. Distribution of foot arch type (%) by Harris imprint index (HII), Chippaux-Smirak index (CSI), and Staheli index (SI)

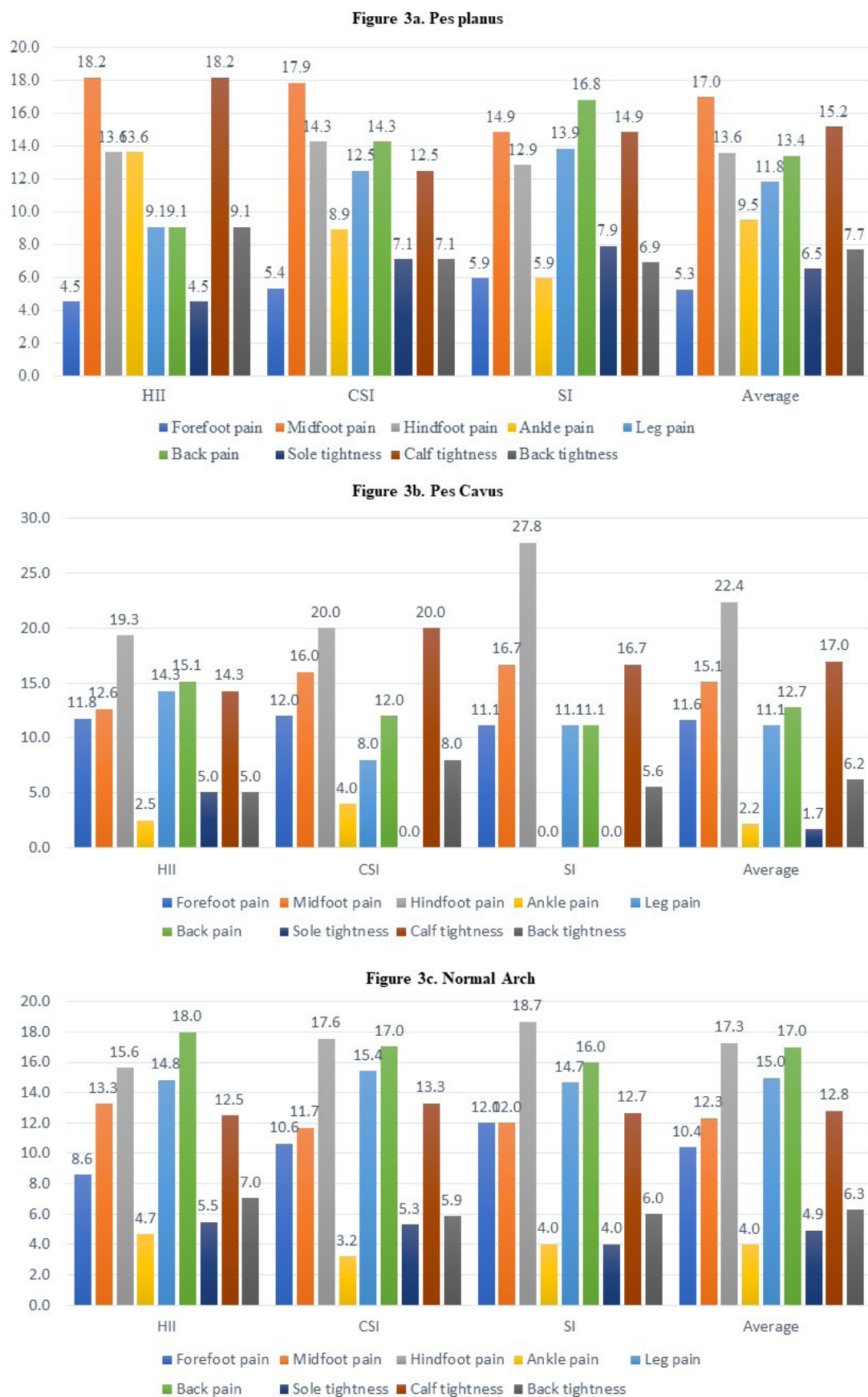


Fig 3. The associated symptoms (%) divide by foot arch type: Pes Planus (3a.), Pes Cavus (3b.), Normal arch (3c.)

TABLE 2. Factors associated with moderate to severe pain (NRS ≥ 4)

Factors	Odds ratio	95%CI	p-value
Gender	0.97	0.55 - 1.72	0.929
BMI ≥ 23 kg/m ²	3.23	1.63 - 6.41	0.001
Standing/ walking duration ≥ 8 hours per day	0.61	0.32 - 1.15	0.123
Shoe type on study day			
Flat shoe	0.49	0.24 - 0.98	0.045
Sneaker shoe	1.14	0.52 - 2.49	0.742
Sport shoe	1.31	0.55 - 3.11	0.540
Sandal	1.00	-	-
Arch of foot type by Harris imprint index			
Pes planus	1.07	0.39 - 2.88	0.898
Pes cavus	1.06	0.58 - 1.92	0.852
Arch of foot type by Chippaux-Smirak index			
Pes planus	0.90	0.42 - 1.92	0.786
Pes cavus	0.25	0.08 - 0.74	0.012
Arch of foot type by Staheli index			
Pes planus	1.00	0.53 - 1.87	0.993
Pes cavus	0.24	0.07 - 0.81	0.021

Abbreviation: BMI = body mass index

Definitions of shoe type: flat shoe = a shoe with flat heels or no heels, sneaker shoe = a casual rubber-soled shoe, sport shoe = a shoe designed to be worn for sports, exercising, or recreational activity, sandal = an open-toed shoe consisting of a sole strapped to the foot

Definition of shoe type on working day was the same pair of shoes that the medical students always wear during study period.

Therefore, this study mostly found the midfoot pain in the medical students with pes planus. However, pes cavus is characterized by an abnormally high medial longitudinal arch of foot. The plantar pressure of pes cavus was high at the heel and lateral forefoot area during walking.¹⁵ Thus, the students with pes cavus mostly had hindfoot pain in this study. Low back pain was found in all groups of foot arch type. A previous study showed patients with pes planus had intermittent low back pain about 15% while this study had about 13.4%.¹⁶ Interestingly, the previous study showed that foot posture was not associated with low back pain.¹⁷

Almost half of the medical students had moderate to severe pain (NRS ≥ 4) in their foot or leg. The researcher would like to evaluate the risk factors that are associated with moderate to severe pain. Moreover, the previous study showed that in patients with moderate to severe pain classification (NRS ≥ 4) their quality of life and functions

might be interfered with.⁹ This study found that medical students with overweight to obesity classification was a significant risk factor for moderate to severe pain (OR = 3.23, 95%CI 1.63 - 6.41, p-value = 0.001). Similarly, the previous study showed severe obesity was associated with the foot pain compared with the control group (OR 4.2, p<0.001).¹⁸ Obesity in men and overweight to obesity classification in women were associated significantly with foot pain.¹⁹ Flat shoes could help to reduce the foot pain. Therefore, medical students may be advised to control their BMI and choose flat shoes to prevent their foot pain.

Limitation of this study, the other foot conditions as hallux valgus, callus, and the shoe conditions as comfortable level in wearing, inappropriate shoe size that could cause their pain were not included. Also, the effect of pain on learning ability, quality of life, and psychological problems were not evaluated.

CONCLUSION

Bilateral normal arched feet were mostly found in 5th year medical students, Faculty of Medicine, Thammasat University. Midfoot pain in pes planus and hindfoot pain in pes cavus and normal arched foot were the most common symptoms and BMI was a risk factor.

Author contributions

Conceptualization: Paecharoen S. Methodology: Paecharoen S, Kritsanapraneet T. Formal analysis: Paecharoen S. Project administration: Paecharoen S, Kritsanapraneet T. Visualization: Paecharoen S. Writing – original draft: Paecharoen S. Writing – review and editing: Paecharoen S, Kritsanapraneet T. Approval of final manuscript: all authors.

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