The Relationship Between Gender and BMI on the Pattern and Height of Pedic Arches

Hindun Saadah[1], Gita Aulia Sigit Putri[2], Sony Ramdhani[2], Hikmat rudyana[3],
[1]Departemen Anatomi Fakultas Kedokteran Universitas Jenderal Achmad Yani, Cimahi, Jawa Barat, Indonesia, [2]Departemen Forensik dan Medikolegal Universitas Jenderal Achmad Yani, Cimahi, Jawa Barat, Indonesia, [3]Fakultas Ilmu dan Teknologi Kesehatan Universitas Jenderal Achmad Yani Cimahi, Jawa Barat, Indonesia
Email: hindun.saadah@gmail.com

The arcus pedis is composed of bones that form an angle on the sole which acts as a support for body weight and a vibration absorber when the foot contact with a surface. There can be abnormalities of the arch pedis, such as flat foot and cavus foot, as well as pronation and supination. These abnormalities can be caused by genetics, obesity, trauma, and footwear habits. This study aims to determine the relationship between gender and BMI with the pattern and height of the arch of the pedis in Faculty of Medicine Unjani students class of 2021. The study was conducted on 30 students who fulfilled the inclusion criteria. The implementation of this study was in December 2023. This research method is an analytical observational conducted with a cross-sectional approach. This study used the Clarke's Angle method to identify the pedic arch pattern and the Navicular Drop Test to determine the height of the pedic arch. The results of the study were then analysed using the Chi-square test which then showed that there was a significant relationship in BMI to the arch pattern with p = 0.001 (p<0.05) and arch height with p = 0.027 (p<0.05). However, there was no significant correlation between gender and arch pattern with p = 0.749 (p>0.05) and arch height with p = 0.921 (p>0.05). This means that BMI has a role in changing the pattern and height of the pedic arch, but there is no significant effect of gender differences.
Keywords: arch pedis, flatfoot, BMI, gender, low arch.

Corresponding Author:
Hindun Saadah
Departemen Anatomi Fakultas Kedokteran Universitas Jenderal Achmad Yani, Cimahi, Jawa Barat, Indonesia
hindun.saadah@gmail.com

1. Introduction

The foot is part of the lower extremity that is divided into the dorsal and plantar foot regions and plays an important role in controlling body weight. [1,2] The application of biomechanics of movement in humans is related to the structure of the foot that aims to improve performance and prevent and reduce injuries. [3] The foot has an important structure in dampening vibrations when the foot comes into contact with a flat surface, namely the pedis arch which is formed from bones that form an angle on the sole of the foot and is divided into two parts, namely the longitudinal and transverse arches. [4,5] The longitudinal arch is divided into two parts, namely the medial and lateral, which functionally work as a unit in regulating the load and pressure that are the result of body weight, gravity, and the surface of the foot field in all directions. [2] The arch has a pattern and height that can experience abnormalities due to the influence of the condition of the tendons, muscles, ligaments, or bones that support it. In the medial longitudinal arch, the common arch pattern abnormalities are *flat feet* and *cavus feet,* while the height abnormalities of the pedis arch are *pronation* and *supination.* [6]

Flat feet is a condition of the foot arch disorder that most often occurs due to weakening of the structures that support the foot arch, such as the intrinsic muscles of the foot, the plantar ligament, the anterior and posterior tibial tendons, which results in the loss of the foot arch in the longitudinal arch. [6] Several factors such as BMI, gender, genetics, and footwear use are known to play a role in changes in the pattern and

height of the foot arch. In contrast to *flat feet, Cavus foot,* also known as *pes vagus,* is a condition where the arch of the foot is too high. [7] The exact cause of *cavus foot* is still unknown. [8] A curve that is too low or too high can interfere with activities and increase the risk of musculoskeletal injuries due to uneven body weight support, especially in overweight individuals. [9] Arch disorders include fatigue and pain. This disorder is more likely to occur if someone has a *flat foot* that tends toward pronation or *a cavus foot* (*supination),* which can interfere with daily activities. *Flat feet* and cavus *feet* can occur unilaterally or bilaterally. The potential impact of a foot arch abnormality on one side is a difference in lower extremity height, which can lead to pelvic tilt, ultimately leading to scoliosis as compensation for the vertebral curve .

The purpose of this study was to examine the relationship between gender and BMI on the arch pattern and height of the pedis in the 2021 Faculty of Medicine, Unjani, students. Rapid mobility is increasingly required for medical students as they enter the *co-assistant stage.* Students can maximize their work time if supported by high energy and endurance, normal foot anatomy, good static and dynamic balance, and agility. [11] Understanding the shape of the arch of the foot can also provide insight into ergonomic shoe shapes and the selection *of insoles* that adapt to the arch. These shoe choices can help, support, and enhance work activities and productivity .

2. Materials And Methods

This research is an analytical *cross-sectional study* that examines the description and relationship between gender and BMI on the pattern and height of the pedis arch in students of the Faculty of Medicine, Unjani, Indonesia. Respondents in this study were 30 students of the Faculty of Medicine, Unjani, class of 2021 who met the inclusion criteria, namely attending lectures, having a BMI ranging from *underweight* to obesity level II, and willing to sign an *informed consent form.* Sampling in this study was carried out using a *purposive sampling method.* Prior to data collection, this study had received approval from the Unjani ethics committee with No. *ethical approval* 077/UM1.12/2023. Data collection went through several procedures, namely measuring body weight with a scale and height with *a microtoise,* the results of which were calculated using the BMI formula. Next, respondents measured the height of the pedis arch using *the Navicular Drop Test method,* which determines the point *of the navicular tuberosity* when *the subtalar* is in a neutral and relaxed state. Then, respondents printed their feet with watercolors on a white cloth, forming the arch of the foot. This was interpreted using *Clarke's angle.* Univariate data were analyzed using *crosstabs,* and bivariate data were analyzed using the *Chi-Square test.*

3. Results and Discussion

Description of Arch Pattern and Height Based on Gender

With univariate analysis, a description of the characteristics of the pattern and height of the pedis arch based on gender of 30 respondents was obtained, as shown in Table 1.

Table 1. Description of the pattern and height of the pedis arch based on gender.

Variables	Arch Pedis Pattern						Arch Height					
	Cavus Foot		Normal		*Flat Foot*		*Supination*		Normal		*Pronation*	
Gender	n	%	n	%	n	%	n	%	n	%	n	%
Man	0	0	7	23.3	6	20.0	1	3.3	5	16.7	7	23.3
Woman	0	0	7	23.3	10	33.3	3	10.0	8	26.7	6	20.0
Total	0	0	14	46.7	16	53.3	4	13.3	13	43.3	13	43.3

Based on Table 1, of the 13 male respondents, 7 (23.3%) had a normal arch pattern, outnumbering the 6 (20.2%) with a *flat foot pattern.* Among the 17 female respondents, the predominant arch pattern was *flat foot,* with 10 (33.3%). This finding aligns with research conducted by Kachoosangy et al. ([2013]) which found that women have a slightly higher prevalence of flatfoot *compared* to men.ADDIN CSL_CITATION {"citationItems":[{"id":"ITEM-1","itemData":{"ISSN":"17353610","abstract":"Objectives: The aim of this study was to determine the prevalence of flat foot in a population of 7-12 year old students and to investigate the relationship between flat foot and age and sex. Method: In this cross-sectional study, a total of 945 students (460 girls and 485 boys) were examined. The presence of flatfoot and the degree of its severity according to Tachdjian's system of grading for flatfoot was assessed. Results: The data showed that the overall prevalence of flat foot was 74% out of which 23% were mild, 34% were moderate and 17% were severe. The prevalence of flat foot in girl and boy students were 75.2% and 72.6% respectively, but this difference was not significant. Moreover, no significant relationship was observed between the prevalence of flat foot and age.

Description of Arch Pattern and Arch Height Based on BMI

The pattern and height of the pedis arch of the respondents that had been obtained were also subjected to univariate analysis tests with the BMI variable and produced a description of the characteristics of the pattern and height of the pedis arch based on BMI which can be explained in Table 2.

Table 2 Description of Arch Pattern and Height Based on BMI

Variables	Arch Pedis Pattern						Arch Height					
	Cavus Foot		Normal		*Flat Foot*		*Supination*		Normal		*Pronation*	
BMI	n	%	n	%	n	%	n	%	n	%	n	%
Underweight	0	0	2	6.7	1	3.3	2	6.7	0	0	1	3.3
Normal	0	0	9	30.0	2	6.7	2	6.7	9	30.0	0	0
Overweight	0	0	3	10.0	3	10.0	0	0	3	10.0	3	10.0
Type 1 obesity	0	0	0	0	6	20.0	0	0	1	3.3	5	16.7
2 obesity	0	0	0	0	4	13.3	0	0	0	0	4	13.3
Total	0	0	14	46.7	16	53.3	4	13.3	13	43.3	13	43.3

flat foot arch pattern was found in respondents with a BMI of type 1 obesity, totaling 6 people (20%), followed by respondents with a BMI of type 2 obesity, totaling 4 people (13.3%). Respondents with a normal BMI had the most normal arch pattern, namely 9 people (30%), while respondents with an *overweight BMI* had the same number of normal arch patterns and *flat feet,* namely 3 people (10%). In this study, no *cavus foot* arch *pattern was found* in 30 respondents. It was also found that low arches were most often experienced by respondents with a BMI of type 1 obesity, as many as 5 people (16.7%). This figure concludes that BMI influences the pattern and height of the pedis arch, in accordance with research conducted by Saadah et al. (2022) and Ramadany et al. (2021) who also found that many students with *overweight BMI,* type 1 obesity, and type 2 obesity had flat feet. [17]

Relationship between Gender and Arch Pattern and Height

The bivariate analysis conducted in this study aimed to determine the relationship between BMI and gender on the arch pattern and height of the foot. The relationship between gender on the arch pattern and foot height is shown in Table 3 and on the arch height in Table 4.

Table 3 Relationship between gender and pedis arch pattern

Variables	Gender				*P-Value*
	Man		Woman		
	n	%	n	%	
Arcus Pattern					
Cavus Foot	0	0	0	0	0.713
Normal Foot	7	23.3	7	23.3	
Flat Foot	6	20	10	33.3	
Total	13	43.3	17	56.7	

Based on Table 3, after analysis using the *Chi-square test, a p-value* of 0.713 (>0.05) was obtained, indicating no significant relationship between gender and the arch height pattern. Similarly, Table 4 shows the results of the *Chi-square* test analysis with a *p-value* >0.05 (0.721), indicating no significant relationship between gender and arch height.

These results are consistent with research conducted by Aenumulapall i, et al. (2017) and Abaraogu, et al. (2016), which stated that there was no significant relationship between gender and arch height pattern. [18, 19] The absence of a significant relationship between gender and arch height was also found in research conducted by Reddy, et al. (2021) using the same measurement method, namely *the Navicular Drop Test.* [20] There are several factors that are more significant in forming or changing the arch pattern, such as BMI, occupation, genetics, and also footwear use.

Footwear is thought to be a significant factor contributing to gender differences in arch patterns. Women tend to wear footwear that doesn't fit properly or has heels that affect foot position. [15] As found in research conducted by Kumari et al. (2023), there is a significant correlation between *navicular drop and the use of high- heeled* shoes. [21] Wearing high heels will cause stretching of *the plantar fascia* and increase strain on the medial longitudinal arch. [22]

Table 4 Relationship between gender and arch height

Variables	Gender				*P-Value*
	Man		Woman		
	n	%	n	%	
Arch Height					
Normal	5	16.6	8	26.7	0.721
Abnormal	8	26.7	9	30	
Total	13	43.3	17	56.7	

The Relationship between BMI and the Pattern and Height of the Pedicus Arch

Another bivariate analysis test is to look for a relationship between BMI and patterns. and the height of the pedis arch which can be explained in tables 5 and 6.

Table 5 Relationship between BMI and the arch of the foot pattern

Variables	BMI				*P-Value*
	Obese		Non-Obese		
	N	%	n	%	
Arcus Pattern					
Cavus Foot	0	0	0	0	0.000
Normal Foot	0	0	14	46.7	
Flat Foot	10	33.3	6	20.0	

Total	10	33.3	20	66.7	

Table 6 Relationship between BMI and arch height

Variables	BMI				*P-Value*
	Obese		Non-Obese		
	n	%	n	%	
Arch Height					
Normal	1	3.3	12	40	**0.017**
Abnormal	9	30	8	26.7	
Total	10	33.3	20	66.7	

Based on Table 5, 10 students (33.3%) had an *obese BMI and a flat foot* arch pattern. These results were obtained from 6 students with type 1 obesity and 4 students with type 2 obesity. After bivariate analysis, the *p-value was* <0.05, which was 0.000. This value proves a significant relationship between BMI and the arch pattern. The results of this study are in line with research conducted by Azzahra et al. (2020) which found a significant relationship between BMI and the incidence of *flat feet.* [23]

Based on Table 6, the bivariate analysis results obtained *a p-value* <0.05, indicating a significant relationship between BMI and arch height. This finding aligns with research conducted by Zhao et al. (2020), which stated a relationship between BMI and arch height. [24] This study also aligns with research conducted by Jafarnezhadgero et al. (2023), which found a strong relationship between weight gain and arch height. [25]

Overweight individuals are at increased risk of changes in foot posture, leading to *flat feet* and a low arch. [26] A high BMI can increase body weight, thereby increasing the load on the feet. This condition causes damage to the medial longitudinal arch structure and decreases the elasticity of the heel fat pad, which leads to a decrease in arch height and changes in foot posture. [27]

4. Conclusion

Based on the research results, it was found that the condition of flat feet (*flat feet* and *pronation*) This is most often found in students with type 1 obesity. Female students also experience this condition most often. After conducting a bivariate analysis, a significant relationship was found between BMI and the arch pattern and height of the foot, but no significant relationship was found between gender and the arch pattern and height.

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