Pak. j. life soc. Sci. (2024), 22(2):16217-16226 E-ISSN: 2221-7630;P-ISSN: 1727-4915

Pakistan Journal of Life and Social Sciences
www.pjlss.edu.pk

https://doi.org/10.57239/PJLSS-2024-22.2.001175

RESEARCH ARTICLE

The Relationship of Shoe Ergonomics to Pain Intensity Calcaneus and Hallux Valgus

Fifi Ishak[1,2], Irene Edith Rieuwpassa[3], Muhammad Iqbal Basri[4]

[1]Biomedical Science Student, Graduate School, Hasanuddin University, Indonesia
[2]Faculty of Health Sciences, Muhammadiyah University of Gorontalo
[3]Faculty of Dentistry, Hasanudin University, Indonesia
[4]Faculty of Medicine, Hasanuddin University, Indonesia

ARTICLE INFO

Received: Sep 18, 2024

Accepted: Nov 20, 2024

Keywords

Pain Calcaneus,

Hallux Valgus,

High Heels,

Types of shoes

***Corresponding Author:**

fifiishak@umgo.ac.id

ABSTRACT

Painful Calcaneus is an abnormal finding and is closely related to the symptom of heel pain. Hallux Valgus (HV) or commonly called a bunion or stiff big toe is a deformity of the first toe and big toe. This condition occurs when the first metatarsal experiences lateral deviation with rotation, this condition is accompanied by or without medial widening of the soft tissue on the distal part of the metatarsal. The study aims to determine the ergonomics of shoes on the intensity of calcaneus pain and the incidence of hallux valgus among BRI bank employees in Gorontalo district. This research uses an analytical survey research type with a cross-sectional research design, with a sample size of 91 female respondents, with an age range of 20-50 years. The variables in this study were Calcaneus pain intensity, Hallux Valgus, Age, BMI, type of shoe, high heels, length of standing. Based on Multivariate analysis with Simultaneous Test (F Test) on the intensity of calcaneus pain, a value of 0.000 was obtained. This shows that there is a significant influence among the five independent variables (Age, BMI, Height of High Heels, Length of Standing) on the level of pain simultaneously (p-value<0,05). Based on multivariate analysis with a simultaneous test (F test) on events Hallux Valgus obtained a value of 0.000, this shows that there is a significant influence among the five independent variables (age, BMI, high heels, length of standing) on the incidence Hallux Valgus simultaneously (p-value<0,05).

INTRODUCTION

The foot is the part of the body from the ankle to the toes. The heels and toes are equipped with soft tissue which is a cushion to withstand the weight of the body pressing on the area. Because the function of the foot is to bear weight, the heels, soles and feet often experience problems. Ergonomics in foot dimensions includes foot type analysis, foot movement, shoe perforation analysis, foot pressure analysis and anthropometric analysis. Analysis is carried out to determine and obtain dimension limits and standardization. These dimensional limitations provide a level of fit and comfort for foot activities (Hylton, 2016).

In the heel area you can find a bone called the calceneus. The calcaneus is the largest part of the tarsal bone located under and behind the foot. One of the abnormalities in this bone is known as calcaneus pain. Calcaneus pain is an abnormal finding and is closely related to the symptom of heel pain.

The use of high heels with a height of more than five centimeters, places the feet in a state of plantar flexion. This position can trigger continuous contraction of the gastrocnemius muscle to maintain a balanced standing position so that tension in the muscle fibers increases and makes the gastrocnemius muscle tense, causing pain.

Hallux Valgus (HV) or commonly called a bunion or stiff big toe is a deformity of the first toe and big toe. This condition occurs when the first metatarsal experiences deviation laterally with rotation, this condition is accompanied by or without medial widening of the soft tissue in the distal part of the metatarsal (Daeli, 2020; Justin, 2019).

Wearing high heels adjusts your body posture by changing the position of the feet, elevating the heel bone and flexing the tibiotalar joint, changing body weight and disrupting postural balance, (Wulan and Astriani, 2016). This is one of the impacts of wearing high heels, which in this case has a direct effect on the distribution of body pressure on the feet. This condition is related to foot deformities such as bunions, because changes in the distribution of body pressure on the feet manifest as increased pressure on the front of the foot.

Calcaneus pain often occurs in adults, office workers and even athletes. This incidence reaches 11.5 per 100 people, more often in women. In women, it was recorded as 16.5 people per 100,000 people per year with a peak age of 20 to 45 years. A high prevalence of HV has been demonstrated in the literature, reaching approximately 35% of the adult population. HV has long been one of the most common chronic foot complaints, presenting commonly in foot and ankle clinics throughout the world. According to recent reports covering America, Germany, Russia, Spain and China, the incidence of HV is 23% in seniors aged 18 to 65 years and 35.7% in those aged over 65 years. This incidence may be greater, due to genetics and could also be due to the increased use of shoes that are inappropriate or less suitable. *Hallux Valgus* is difficult to treat and has a high risk of recurrence and disability.

METHOD

This research uses an analytical survey research type with a cross sectional research design. This research was conducted at Bank BRI in Gorontalo district, from 12 August – 16 September 2024. The subjects were 91 respondents, with inclusion criteria: female employees aged 20-50 years, had worked for a minimum of 12 months, have a BMI of more than 25, wear high heels with a height of more than 1 inch = 2.5 cm, agree to provide informed consent to become respondents. With exclusion criteria: there are wounds in the calcaneus area, congenital abnormalities in the feet, trauma.

The results of the VAS questionnaire are a pain scale measured using a cm scale ruler which is then grouped into several categories, namely 0 - 0.4 cm in the no pain category, 0.5 - 4.4 cm in the mild pain category, 4.5 - 7.4 cm moderate pain category, 7.5-10 cm severe pain category. For hallux valgus, measurements are made using a goniometer with the center of rotation of the goniometer placed at the MTP joint on the medial side of the foot. One arm of the goniometer was placed parallel to the medial aspect of the first metatarsal and the other arm was placed on the medial aspect of the proximal phalange of the hallux. This is done by measuring three times and taking the average. Data analysis used in this research used SPSS. The classification of HV angles can be divided into non-HV and HV. It is said to be not HV if the angle is $< 15^0$ and it is said to be HV if the angle is $> 15^0$.

RESULTS

Respondent characteristics based on age, height, weight, duration of work (hours/days), length of service.

Table 1. Characteristics of respondents

Respondent Characteristics	Number (N)	Percentage (%)
Age (Years)		
16-25	5	5,5
26-35	59	64,8
36-45	26	28,6
46-55	1	1,1
Height (cm)		
151-160	67	73,6
161-170	24	26,4
Body Weight (kg)		
51-65	87	95,6
66-80	4	4,4
Working Duration (hours/day)		
10	84	92,3
11	7	7,7
Working Time (Years)		
<3	18	19,8
3-5	54	59,3
>5	19	20,9

Univariate Analysis

Table 2. Height of the *High Heels*

Height of the High Heels (cm)	Number (N)	Percentage (%)
3	13	14,3
4	26	28,6
5	41	45,1
6	1	1,1
7	10	11,0
Total	91	100

Based on the table above, it was found that the majority of high heels owned by respondents were high heels with a height of 5 cm, 41 respondents (45.1%). Then followed by high heels with a height of 4 cm as many as 26 respondents (28.6%). Meanwhile, at least 1 respondent (1.1%) has high heels with a height of 6 cm.

Table 3. Length of standing

Long Standing (hours/days)	Number (N)	Percentage (%)
1	3	3,3
2	12	13,2
3	29	31,9
4	31	34,1
5	11	12,1
6	5	5,5
Total	91	100

Based on the table above, it was found that the majority of respondents stood for a long time using high heels, namely 4 hours, 31 respondents (34.1%). Then followed by standing for 3 hours for 29 respondents (31.9%). Meanwhile, at least 3 respondents (3.3%) stood for 1 hour.

Table 4. Body Mass Index

Body Mass Index	Number (N)	Percentage (%)
Normal	69	75,8
Overweight	12	13,2
Obesity	10	11,0
Total	91	100

Based on the table above, it was found that the majority of respondents had a normal body mass index, namely 69 respondents (75.8%). This was followed by 12 respondents (13.2%) who had an overweight body mass index. Meanwhile, at least 10 respondents (11%) had an obese body mass index.

Table 5. Types of Shoes

Shoe Type	Number (N)	Percentage (%)
Cone	16	17,6
Cuban	19	20,9
Spool	23	25,3
Flared	24	26,4
Stiletto	9	9,9
Total	91	100

Based on the table above, it was found that the majority of respondents had flared shoes, namely 24 respondents (26.4%). This was followed by 23 respondents (25.3%) who had spool type shoes. Meanwhile, 9 respondents (9.9%) have stilettos.

Table 6. Pain Level a

Pain Level	Number (N)	Percentage (%)
No Pain	11	12,1
Mild Pain	22	24,2
Moderate Pain	39	42,9
Severe Pain	19	20,9
Total	91	100

Based on the table above, it was found that the majority of respondents experienced moderate pain, namely 39 respondents (42.9%). This was followed by 22 respondents (24.2%) who experienced mild pain. Meanwhile, at least 11 respondents (12.1%) did not experience pain.

Table 7. Incidents of *Hallux Valgus*

Hallux Valgus	Number (N)	Percentage (%)
No	54	59,3
Yes	37	40,7
Total	91	100

Based on the table above, it was found that the majority of respondents did not suffer from hallux valgus, namely 54 respondents (59.3%). Meanwhile, the remaining 37 respondents (40.7%) suffered from hallux valgus.

Multivariate Analysis

Table 8. Simultaneous Test

Model Fitting Information

	Model Fitting Criteria	Likelihood Ratio Tests		
Model	-2 Log Likelihood	Chi-Square	df	Say.

Intercept Only	197.584			
Final	125.161	72.423	15	.000

Based on the table above, the F test value is 0.000. This shows that there is a significant influence between the five independent variables on pain levels simultaneously (*p-value*<0,05).

Table 9. Partial Test (t Test) and Determination Coefficient

Variable	*P-value*	Information	*R*
Age	0,005	Influential	0,594
Height of High Heels	0,045	Influential	
Length of Standing	0,017	Influential	
Body Mass Index	0,013	Influential	
Shoe Type	0,011	Influential	

Based on the table above, it is obtained that the value *p-value* all five independent variables are below 0.05. This shows that partially the five independent variables have a significant effect on pain levels. From the table above, a coefficient of determination value of 0.594 is also obtained, which means that the independent variable is able to explain or influence the dependent variable by 59.4%. The remaining 40.6% is explained by other variables not included in this research.

Table 10. Multinomial Logistic Regression Model Equation

Pain Level	Variable	Beta	Say
No Pain	constant	27,68	0,000
	Age	-3,90	0,008
	Height High Heels	-3,34	0,064
	Length of Standing	-0,12	0,833
	Body Mass Index	-1,74	0,139
	Shoe Type	-0,14	0,909
Mild Pain	constant	17,46	0,000
	Age	-2,51	0,005
	Height High Heels	-0,32	0,578
	Length of Standing	-0,89	0,029
	Body Mass Index	-0,95	0,080
	Shoe Type	-1,21	0,044
Moderate Pain	constant	16,18	0,000
	Age	-1,76	0,027
	Height High Heels	0,18	0,717
	Length of Standing	-0,99	0,011
	Body Mass Index	-1,64	0,004
	Shoe Type	-1,52	0,006

Equation Model I:

$$\mathbf{Ln}\left(\frac{P(no\ pain)}{P(severe\ pain)}\right)) = \mathbf{27,68 - 3,90X_1}$$

With interpretation:

1. The older you are, the greater the chance of experiencing severe pain compared to not experiencing pain

Model II equation:

$$\mathbf{Ln}\left(\frac{P(mild\ pain)}{P(severe\ pain)}\right)) = \mathbf{17,46 - 2,51X_1 - 0,89X_3 - 0,89X_5}$$

With interpretation:

1. The older you get, the greater the chance of experiencing severe pain compared to mild pain

2. The greater the duration or length of standing, the greater the chance of experiencing severe pain compared to mild pain

3. The greater the type of shoe used, the greater the chance of experiencing severe pain compared to mild pain

Model III equation:

$$\mathbf{Ln}\left(\left(\frac{P(mild\ pain)}{P(severe\ pain)}\right) = \mathbf{16.18 - 1.76X_1 - 0.99X_3 - 1,64X_5 - 1,52X_5}\right.$$

With interpretation:

1. The older you get, the greater the chance of experiencing severe pain compared to moderate pain

2. The greater the duration or length of standing, the greater the chance of experiencing severe pain compared to moderate pain

3. The greater the type of shoe used, the greater the chance of experiencing severe pain compared to moderate pain

Table 11. Odds Ratio

Pain Level	Variable	Exp (B)
No Pain	Age	0,020
Mild Pain	Age	0,082
	Length of Standing	0,408
	Shoe Type	0,301
Moderate Pain	Age	0,172
	Length of Standing	0,011
	Body Mass Index	0,373
	Shoe Type	0,220

Based on the table above, it can be concluded as follows:

1. Value *OR* of 0.020 in the age category and the no pain category, indicating that as a person gets older, they tend to suffer from severe pain by 0.020 times more than those who do not experience pain.

2. Value *OR* amounting to 0.082 in the age category and the mild pain category shows that as a person gets older, they tend to suffer from severe pain 0.082 times more than mild pain

3. Value *OR* amounting to 0.408 in the long standing category and the mild pain category shows that the longer a person stands, the more likely they are to suffer from severe pain by 0.408 times compared to mild pain.

4. Value *OR* amounting to 0.301 in the shoe type category and the mild pain category shows that if a person increases the level of shoe type, they will tend to suffer from severe pain by 0.301 times compared to mild pain

5. Value *OR* amounting to 0.172 in the age category and the moderate pain category shows that as a person gets older, they tend to suffer from severe pain 0.172 times more than moderate pain

6. Value *OR* of 0.011 in the long standing category and the moderate pain category, indicating that the longer a person stands, the more likely they are to suffer from severe pain by 0.011 times compared to moderate pain.

7. Value *OR* of 0.373 in the body mass index category and the moderate pain category, indicating that the more a person increases their body mass index, the more likely they are to suffer from severe pain by 0.373 times compared to moderate pain.

8. Value *OR* amounting to 0.220 in the shoe type category and the moderate pain category, indicating that if a person increases the level of shoe type, he or she will tend to suffer from severe pain by 0.220 times more than moderate pain.

Table 12. Simultaneous Test

Omnibus Tests of Model Coefficients

		Chi-square	df	Say.
Step 1	Step	64.162	5	.000
	Block	64.162	5	.000
	Model	64.162	5	.000

Based on the table above, the simultaneous test value is 0.000. This shows that there is a significant influence between the five independent variables on the occurrence of hallux valgus simultaneously (*p-value*<0,05).

Table 13. Partial Test and Coefficient of Determination

Variable	*P-value*	Information	*R*
Age	0,002	Influential	0,683
Height of High Heels	0,021	Influential	
Length of Standing	0,024	Influential	
Body Mass Index	0,019	Influential	
Shoe Type	0,047	Influential	

Based on the table above, it is obtained that the value *p-value* all five independent variables are below 0.05. This shows that partially the five independent variables have a significant effect on the incidence of hallus valgus. From the table above, a coefficient of determination value of 0.683 is also obtained, which means that the independent variable is able to explain or influence the dependent variable by 68.3%. The remaining 31.7% is explained by other variables not included in this study.

Table 14. Binary Logistic Regression Model Equation

Variable	Beta
constant	-20,517

Age	2,242
Height of High Heels	1,504
Length of Standing	0,706
Body Mass Index	1,114
Shoe Type	0,844

Based on the table above, the following logistic regression equation can be obtained:

$$\ln\left(\frac{P(y-1)}{1-P(y-1)}\right) = -20{,}517 + 2{,}242X_1 + 1{,}504X_2 + 0{,}706X_3 + 1{,}114X_4 + 0{,}884X_5$$

with the following interpretation:

1. The constant value is -20.517, which means that if the value of all independent variables is equal to zero, will decrease *log-odds* value of a person experiences hallux valgus incidence of 20,517.

2. β_1 value equal to 2.242, which means that if the age value increases by one unit, will increase *log-odds* value a person experiences a hallux valgus incidence of 2,242.

3. β_2 value equal to 1.504, which means that if the value of high heels increases by one unit, will increase *log-odds* value a person experiences a hallux valgus incidence of 1.504.

4. β_3 value of 0.706, which means that if the value of the length of standing increases by one unit, will increase *log-odds* value a person experiences a hallux valgus incidence of 0.706.

5. β_4 value is 1.114, which means that if the body mass index value increases by one unit, will increase *log-odds* value a person experiences a hallux valgus incidence of 1.114.

6. β_5 value of 0.844, which means that if the value of the type of shoe increases by one unit, will increase *log-odds* value a person experiences a hallux valgus incidence of 0.844.

Table 15. Odds Ratio

Variable	Exp (B)
Age	9,415
Height of High Heels	4,499
Length of Standing	2,026
Body Mass Index	3,046
Shoe Type	2,327

1. value of *odds ratio* for age variable was obtained at 9.415, which means that the respondent's chance of experiencing hallux valgus will increase by 9.415 for each increase in age compared to before.

2. Value *odds ratio* of the height of high heel variable was obtained at 4.499, which means that the respondent's chance of experiencing hallux valgus will increase by 4.499 for every increase in high heel height compared to before.

3. Value *odds ratio* of The length of standing variable was obtained at 2.026, which means that the respondent's chance of experiencing an incident *gray light* will increase by 2.026 for every increase in length of existence compared to before

4. Value *odds ratio* of The body mass index variable was obtained at 3.046, which means that the respondent's chance of experiencing hallus valgus will increase by 3.046 for every increase in body mass index compared to before.

5. Value *odds ratio* The shoe type variable was obtained at 2.327, which means that the respondent's chance of experiencing hallux valgus will increase by 2.327 for each increase in shoe type compared to before.

DISCUSSION

The use of High Heels causes the position of the feet, ie *ankle* are in a plantarflexed position and the toes are in an extended position. Plantarflexion *ankle* position and extension of the toes causes stretching excess plantar fascia so that injuries to the plantar fascia will occur more easily. Injury to the plantar fascia is called plantar fasciitis, the clinical manifestation of which is pain in the medial calcaneus area. The more injuries that occur to the plantaris fascia, the intensity of pain felt in the medial calcaneus will also increase. In this research, it was found that the majority of respondents experienced moderate pain, namely 39 respondents (42.9%). This was followed by 22 respondents (24.2%) who experienced mild pain. Meanwhile, at least 11 respondents (12.1%) did not experience pain. Based on the SPSS test results, the F test value is 0.000. This shows that there is a significant relationship between the four independent variables and the level of pain simultaneously (*p-value*<0.05). This is in line with previous research, namely the level of pain experienced by 50 participants who wore high heels for 6 hours was evaluated. They assessed pain in the shoulders, back, hips, thighs, knees, legs, ankles, toes, metatarsals and calcaneus using a pain scale ranging from 0 to 10. It was seen that the higher the heel, the greater the pain experienced when wearing heels. tall. The pain experienced by the subjects appears to be due to two main causes: excessive pressure and muscle fatigue. Pain at bony prominences is most likely caused by excessive pressure and pain in other locations is most likely caused by muscle fatigue (Kadek, 2021). The back, metatarsals, and calcaneus experience the most pain when wearing high heels. Prolonged use of high heels is also known to increase pain in the middle of the foot (Yun, 2022). Reduced support, due to poor footwear design, results in increased foot pressure, especially on the metatarsal heads, leading to changes in the center of pressure (COP) (Hour, et al., 2024).

Hallux valgus (HV) is a deformity of the first toe or big toe. This condition occurs when the first metatarsal experiences medial deviation and the big toe experiences lateral deviation with rotation (James and Farhan, 2023). This condition is accompanied by or without medial widening of the soft tissue on the distal part of the metatarsal. The causes of Hallux Valgus are multifactoral. However, one of the causes of Hallux Valgus is the use of high heels. Based on existing theory, hallux valgus can occur due to the use of footwear which causes the thumb to be pushed continuously towards the other fingers, usually the thumb is pushed towards the other finger. The respondent has been using this type of footwear for more than 3-10 years, so that during the examination the thumb was bent towards the other fingers. The respondent's finger bending was checked using a goniometer and the results were a bend of $>15^0$ experienced by respondents. In accordance with the theory which states that women more often experience this disorder, the same thing happened to research respondents, namely female employees with a majority age of 20 - 50 years. The results of the research showed that 40.7% of respondents had hallux valgus. This is in line with previous research which stated that

subjects with high heels-inarrow toe box developed HV compared to subjects wearing flat shoes – wide toe box was 2.63 times higher (95% CI: 1.00-6.90) and significant statistically (p *p*= 0.046). Similarly, subjects wearing high heels with a wide toe box were 2.7 times (95% CI: 1.01-7.23) more at risk for developing HV when compared with subjects wearing flat shoes – wide toe box *(*p = 0.043). In other words, subjects with high-heeled toe boxes had the same risk as subjects with narrow-high heel toe boxes for developing HV (Dewi, et al., 2019). Wearing shoes with a heel height of 6 cm without the distraction of a narrow box-shaped toe can cause PPH abduction and valgus deviation associated with HAV formation (Ruben, 2019).

CONCLUSION

Based on the results and discussion, it can be concluded that There is a significant relationship between high heels and pain *Calcaneus* with value *p* value = 0,000. There is no significant relationship between long standing and pain *Calcaneus* with value *p* value = 0,581. There is a significant relationship between Body Mass Index and Pain *Calcaneus* with value *p* value = 0,032. There is a significant relationship between shoe type and pain *Calcaneus* with a p value = 0,000. There is a significant relationship between high heels and pain *Calcaneus* with value *p* value = 0,000. There is a significant relationship between the height of high heels and *Hallux valgus* with a p value = 0,000. There is no significant relationship between long standing and *Hallux valgus* with value *p* value = 0,0345. There is a significant relationship between body mass index and *Hallux valgus* with value *p* value =0,010. There is a significant relationship between the type of shoe and hallux valgus and value *p* value =0,000.

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