

Relationship of Flat Foot and Plantar Fascia Thickness in Medical Students of Pelita Harapan University

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Abstract

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Background : Plantar fascia plays significant role in supporting the height and structure of Medial Longitudinal Arch (MLA). In flat foot, the MLA is depressed. There is thickening of plantar fascia reported in cases of plantar fasciitis in subjects with flat foot. Therefore, research needs to be done to investigate the relation between flat foot and plantar fascia thickness.

Aim: To understand the relationship between flat foot and plantar fascia thickness among medical students of Pelita Harapan University.

Methods : This study was conducted using cross-sectional method with sampling method of non-random consecutive sampling. Data was collected through examinations performed and adjustments are made using inclusion and exclusion criteria. Flat foot was determined using navicular drop test and plantar fascia thickness was assessed using ultrasonography measurement. Results were analyzed using SPSS 22.0 and statistically tested using Spearman's rho test.

Result : The analysis of the relationship between flat foot and plantar fascia thickness showed positive correlation with correlation coefficient of 0.634 on the right foot and 0.443 on the left.

Conclusion : There is moderate and strong positive relationship between flat foot and plantar fascia thickness among medical students of Pelita Harapan University.

Introduction

Flat foot is a type of foot arch that is present in 10-25% adult population¹ and is associated with the increase of musculoskeletal symptoms felt.² Flat foot is characterized by medial longitudinal arch (MLA) depression, eversion of rearfoot and midfoot abduction and dorsiflexion.^{3,4} Plantar fascia is one of the most important structure in maintaining the height of MLA. Study done by Huang et al. in 2004 showed that there is an increased plantar fascia thickness in some cases of plantar fasciitis found in subjects with flat foot. This is due to *microtears* and inflammatory response in plantar fascia that results in thickening of

the fascia as a compensation and healing process from withstanding heavy load.

Plantar fascia forms a strong fascia band that extends from the rough surface of calcaneus to the toes. Plantar fascia (PF) plays an important role in maintaining foot arch⁵, mainly because it provides primary passive support that maintains the structure and height of MLA.⁶ In weight bearing position when standing up, the pressure that came from extension of PF acts as a bond on the MLA to minimize the drop of foot arch.⁷

Plantar fasciitis is the most common cause of heel pain.⁸ Plantar fasciitis is associated with biomechanical factors like flat foot, foot pronation, heel valgus, sudden weight gain or obesity.^{9,10,11} PF thickness > 4mm is associated with plantar fasciitis.^{12,13,14} PF thickening is found in cases of plantar fasciitis with flat foot.¹⁰

Studies have been made to investigate the relation between plantar fasciitis with flat foot, but only a few studies that examines the direct relationship of flat foot and plantar fascia thickness. Hence, this research is done to investigate the relation between flat foot and plantar fascia thickness in university students in Indonesia.

Materials And Method

A total of 34 university students with flat feet from the medical faculty at Pelita Harapan University participated in this study. Data is collected using the navicular drop test method to evaluate flat feet and ultrasonography (US) is used to calculate plantar fascia thickness.

Navicular drop test (NDT) is one of the methods used to evaluate flat feet. Navicular drop is the difference between the distance of *navicular tuberosity* measured to the ground when standing up in a weight bearing position and sitting down (subtalar neutral position).¹⁵ Results showing ≥ 10 mm represents flat foot.¹⁶ After the NDT, note the distance of both feet. Next, plantar fascia thickness was measured using ultrasonography.

This is a correlation study with a cross sectional design that is held at Faculty of Medicine on Pelita Harapan University, Karawaci, Tangerang starting from January until April 2019. Samples are obtained using the consecutive sampling technique. Data collected were analyzed using SPSS 22.0 software. Spearman's correlation was used to analyze the data.

Results

Most of the respondents are female (51.8%) with median value of age 20 years old. The mean weight of respondent was 62.41kg with the median of 61kg. The mean height of respondents is 165.4cm with the median value of 165cm. Mean BMI of the respondents are 22.68 kg/m² with the median value of 23.25 kg/m². Male group have a higher BMI with the mean value of 23.71 kg/m² when compared to the mean BMI of female group with the value of 21.95 kg/m².

Table 1. Subject characteristics

Subject characteristics (n=34)	n	Min	Max
Gender			
Male	14 (41.2%)	-	-
Female	20 (58.8%)		
Age (years)			
Mean \pm SD	20.26 \pm 0.86	18	22
Median	20		
Weight (kg)			
Mean \pm SD	62.4 \pm 10.1	47	87
Median	61		
Height (cm)			
Mean \pm SD	165.4 \pm 8.7	150	188
Median	165		
Body Mass Index (kg/m²)			
Mean \pm SD	22.68 \pm 2.06	18.6	24.9
Median	23.25		
Plantar Fascia Thickness (cm)			
Right foot			
Mean \pm SD	0.33 \pm 0.06	0.21	0.45
Median	0.33		
Left foot			
Mean \pm SD	0.35 \pm 0.06	0.23	0.49
Median	0.34		
NDT (cm)			
Right foot			
Mean \pm SD	1.41 \pm 0.24	1.1	1.9
Median	1.4		
Left foot			
Mean \pm SD	1.48 \pm 0.27	1.1	1.9
Median	1.4		

Table 2. Mean BMI in male and female groups

Gender	Mean \pm SD (BMI)
Male	23.71 \pm 1.78
Female	21.95 \pm 1.95

PF thickness and NDT

Correlation between PF thickness and NDT is done using Spearman’s rho method. Analysis showed correlation coefficient of 0.634 ($p = 0.000$) for right foot and 0.443 ($p = 0.009$) for left foot. Correlation analysis results showed strong correlation between PF thickness and NDT of the right foot and moderate correlation for the left foot.

Table 3. Correlation of PF thickness in left (S) and right foot (D) and NDT

	PF Thickness D – NDT D	PF Thickness S – NDT S
r_s	0.634	0.443

Fig 1. Correlation of PF thickness in right foot (D) and NDT (D)

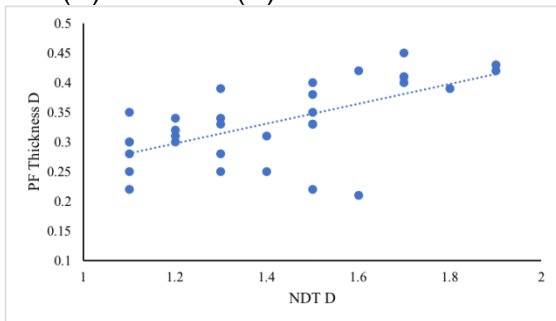
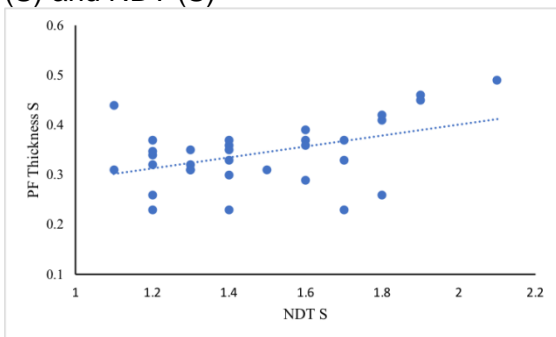


Fig 2. Correlation of PF thickness in left foot (S) and NDT (S)



PF thickness and gender

Analysis using Independent T Test of equal variance is used to assess the mean difference of PF thickness in gender groups. Results shows p value of 0.14 for right foot

and 0.04 for left foot. There no significant mean difference found on right foot, but results are significant for left foot.

Table 4. PF thickness in left and right foot and gender

Gender	Mean ± SD	p value
Right foot		
Male	0.35 ± 0.06	0.14
Female	0.32 ± 0.06	
Left foot		
Male	0.37 ± 0.06	0.04
Female	0.32 ± 0.06	

PF thickness and age

Correlation studies between PF thickness and age are done. Results showed no correlation between PF thickness of right and left foot and age with significance of 0.175 for right foot and 0.197 for left foot.

PF thickness and BMI

It is found that there is no relationship between both variables, PF thickness and BMI with significance of 0.111 for right foot and 0.092 for left foot.

Discussion

PF thickness and flat foot

Results showed that there is a strong relationship between PF thickness of the right foot and flat foot because coefficient correlation of 0.634 is in the range of 0.51-0.75 on the other hand, moderate relationship is found on the left foot because coefficient correlation of 0.443 is in the range of 0.26-0.50.¹⁷ This proves that flat foot curvature is associated with an increase in plantar fascia thickness as evidenced by the presence of a strong and moderate positive correlation between the two variables studied. P value also shows that the results obtained are significant.

The results of this study are consistent with research conducted by Wearing SC et al in 2007 comparing PF thickening and the shape of the foot arch using radiography and regional loading when walking in two

groups of individuals with and without heel pain. Results stated that thickening of PF was positively correlated with CMT1 angle in the foot with heel pain ($r = 0.89$) and the foot without heel pain ($r = 0.64$).⁵

The findings of this study are accordant with the anatomical structure and pathophysiological processes that occur when the arch of the foot is found flat. The condition that occurs in flat foot is that the subtalar joint will remain pronated after the foot becomes flat and the midtarsal joint is not locked.¹⁸ This abnormal condition continues to occur in a weight bearing position and the talocalcaneus joint is continuously subluxated hence, normal gait cycle is not supported. Tibia turns inward, and the foot will be in excessive pronation to allow flattening of the foot. This abnormal walking mechanism will stretch the PF.¹⁹ Repeated traction on the PF will cause microtears and inflammatory response.²⁰ Low arch of the feet will increase the pulling force and repetitive stress on the PF which causes microtears so that the inflammatory response arises to repair the damage. This normal repair process is inhibited by microtrauma resulting from repeated heel strikes that will cause a chronic inflammation of the fascia.¹⁴

PF thickness and gender

Based on the results, there is no significant mean difference found between PF thickness on the right foot in groups of male and female. Contrary to the right foot, a significant mean difference is found on the left foot because the p value was 0.04.

Previous studies conducted by Taş S in 2017 examines the comparison of PF thickness and stiffness and heel fat pad in men and women however, PF thickness measurements were only carried out on the dominant foot. The subjects in this study were 30 women and 30 men with the same age range. The results obtained state that there is a significant difference in PF thickness between groups of women and

men with a p value of 0.037. The average PF thickness in the female group is 3.2 ± 0.5 while in men it is 3.5 ± 0.6 . This can be interpreted that women have a thinner PF thickness when compared to men.²¹ Results are contrary to the study by Abul K in 2015 which assess PF thickness in both foot of 156 subjects without symptoms of heel pain consisting of 88 women (56.4%) and 68 men (43.6%). PF thickness on the left and right foot was found to have a significant difference between groups of women and men with a mean thickness of 2.84 ± 0.42 on the right foot and 2.86 ± 0.44 on the left foot in women while in the male group, the mean thickness was found 3.28 ± 0.56 on the right and 3.3 ± 0.56 on the left. The p value on both female and male foot showed significant results which was <0.001 .²²

The results obtained by the comparative studies above differ from the results in this study, where differences in significance in the right and left foot are found. The difference in significance on the right and left foot can be influenced by differences in the mean and standard deviation of the PF thickness on the left and right foot which may be influenced by differences in NDT values on the right and left foot which are rarely found to have the same value in this study. Different from the comparative studies above which did not examine flat feet but normal feet, so might be no factor that might influence the significant difference of PF thickness found.

The difference in mean PF thickness in the male and female groups can be caused by adaptation as a form of compensation for the increase in load caused by the average male BMI which is greater than women.²¹

PF thickness and age

The relationship between PF thickness and age found to be insignificant in both the right foot (coefficient correlation of 0.175) and the left foot (coefficient correlation of 0.197). The results obtained in this study differ from the results of previous study by Abul K in 2015 which divided 156 samples into two

different age groups. A total of 89 samples (57.1%) are in the age group of 18-39 years while 67 samples (42.9%) are in the age group of 40-65 years. The 18-39 years age group had an average PF thickness of 2.92 ± 0.49 in the right foot and 2.91 ± 0.49 in the left foot, while the 40-65 years age group had a PF thickness in the right foot 3.18 ± 0.54 and the left foot 3.23 ± 0.56 . The p value on the right foot 0.003 and <0.001 on the left foot indicates that there are significant differences in PF thickness in the two age groups. In addition to the paired t test, the researchers also conducted a Pearson correlation test between PF thickness and age which obtained $r = 0.269$ on the right foot $r = 0.327$ where both values showed a moderate relationship.²²

The variation of result between this study and previous study mentioned above may be caused by the age range of subjects of this study is narrow, only from 18 to 22 years old.

PF thickness and BMI

As for BMI, relationship with PF thickness were also insignificant in both the right (coefficient correlation of 0.111) and the left foot (coefficient correlation of 0.092). Research conducted by Taş S et al in 2017 in Turkey revealed that the thickness of PF and BMI had a moderate correlation with coefficient correlation of 0.536.²³ It was found that PF thickness increased in overweight and obese individuals with BMI $\geq 25 \text{ kg / m}^2$.

Congruent with Taş S et al, a study conducted by Uzel M et al in 2005 divided 87 subjects into groups with normal BMI and overweight and obese BMI, found a moderate positive correlation in the Pearson correlation test with a value of $r = 0.319$.²⁴

Research results by Abul K in 2015 also support both studies. Similar to the two studies above, Abul K also divided 156 subjects into two groups based on BMI, namely the group with a normal BMI of 75 people (48.1%) while 81 others were

categorized as overweight and obese BMI. It was found that the group with normal BMI had a smaller average PF thickness compared to the group with overweight and obese BMI, where the difference between the two was statistically significant with p values of 0.002 for the right foot and 0.001 for the left foot. Correlation relationships between the two variables are also analyzed and it shows a moderate relationship with the value of $r = 0.439$ for the right foot and 0.457 for the left foot.²²

The difference in the results obtained can be explained by the exclusion criteria of this study, where samples with a BMI above 25 kg/m^2 were excluded from this study because they were categorized as obese according to WHO Asia Pacific.²⁵ Therefore, the results obtained are certainly different from the three comparative studies above where subjects with overweight and obesity BMI category were included in the data analysis.

This study has several limitations. The use of NDT as a method for determining flat feet can be influenced by the subjectivity of the examiner. In addition, plantar fascia measurement using USG is only done once. Therefore, further research should utilize a more accurate and precise method to determine flat feet and measure plantar fascia thickness more than once so that the results obtained are more exact.

Conclusion

There is moderate and strong positive relationship between flat foot and plantar fascia thickness among medical students of Pelita Harapan University.

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