

# Plantar Fascia Thickness Difference Between Pregnant and Nulliparous in Indonesia

Jeffrey Foraldy<sup>1\*</sup>, Seilly Jehosua<sup>2</sup>, Ansyé Momole<sup>2</sup>, Rizal Tumewah<sup>2</sup>, Theresia Runtuwene<sup>2</sup>, Windy Mariane Virenia Wariki<sup>3</sup>

<sup>1</sup>Department of Neurology, Faculty of Medicine, University of Sam Ratulangi, Manado, Indonesia, <sup>2</sup>Department of Neurology, Faculty of Medicine, University of Sam Ratulangi, Prof. Dr. R. D. Kandou Central General Hospital, Manado, Indonesia, <sup>3</sup>Department of Community Medicine, Faculty of Medicine, University of Sam Ratulangi, Manado, Indonesia

## Abstract

**Background:** Pregnancy is associated with distinct risks of fascia thickness compared to nulliparous. Therefore, this study aimed to compare plantar fascia thickness between asymptomatic pregnant women and nulliparous, evaluating the relationship with age, body mass index (BMI), arch height index (AHI), gestational age, and number of pregnancies. **Methods:** This cross-sectional study was conducted between January and March 2023, and subjects were through a simple random sampling method. The inclusion criteria were subjects aged 18–35 years old, while those with a history of foot pain, trauma, surgery, special orthosis during pregnancy, and other complications were excluded. Fascia thickness was measured at 10 mm distal from the insertion in the calcaneus. Age, BMI, AHI, gestational age, and pregnancy history were recorded. Student's *t*-tests were used to compare both groups. **Results:** The average plantar fascia thickness in pregnant women was  $2.67 \pm 0.44$  mm in both feet, while in nulliparous, it was  $2.24 \pm 0.41$  mm and  $2.26 \pm 0.37$  mm in the right and left foot, respectively. A significant difference was observed between the two groups based on BMI category ( $P < 0.05$ ). Women who had experienced more than one pregnancy showed thicker fascia ( $P < 0.05$ ). In multivariate analysis, BMI (B coefficient:  $0.029-0.031$ ,  $P < 0.05$ ) and number of pregnancies ( $0.268-0.267$ ,  $P < 0.05$ ) had a significant effect on plantar fascia thickness in pregnant women, while age and BMI affected nulliparous. **Conclusion:** Pregnant women had thicker plantar fascia compared to nulliparous. Consequently, screening and prevention in pregnant women and multiparous was necessary to prevent the occurrence of plantar fasciitis.

**Keywords:** Fascia plantar thickness, plantar fasciitis, pregnant, ultrasound

## INTRODUCTION

Pregnancy is associated with the incidence of plantar fasciitis<sup>[1]</sup> as hormonal changes during this period can lead to joint and ligament weakness.<sup>[2]</sup> Enlarged uterus shifts the center of gravity of the body to the posterior capable of flattening the foot arch and adding pressure on plantar fascia.<sup>[3]</sup> These changes, along with the development of oedema and weight gain, collectively impact musculoskeletal balance and body posture.<sup>[3,4]</sup> Pregnancy causes various alterations in the body as it prepares for childbirth. Alteration of the biomechanics, particularly in the lower-extremity joints adapting to absorb extra force, may persist after labor. This condition potentially makes pregnant women more susceptible to a higher risk of lower limb musculoskeletal injuries, specifically in multiparous compared to nulliparous.<sup>[5,6]</sup>

Musculoskeletal ultrasound is a widely available, reliable, and easy method for diagnosing plantar fasciitis. This method is noninvasive and can be safely tolerated in pregnancy, as it does not contain radiation.<sup>[6]</sup> Increased plantar fascia thickness and hypoechoic appearance are sonographic features of plantar fasciitis.<sup>[7]</sup> Mahowald *et al.*<sup>[8]</sup> compiled data from various studies regarding plantar fascia thickness in healthy individuals and observed that the normal thickness in asymptomatic adults ranged from 2.3 to 4.3 mm, with an average of 3.4 mm. Moreover, a thickness exceeding 4.0 mm is considered as abnormal.<sup>[8,9]</sup>

**Address for correspondence:** Dr. Jeffrey Foraldy,

Department of Neurology, Faculty of Medicine, University of Sam Ratulangi,  
Manado, Indonesia.

E-mail: jeffryforaldy@gmail.com

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Previous studies assessed the normal thickness of plantar fascia and fasciitis using ultrasound. However, there is no specific study regarding plantar fascia, particularly in pregnant women. This study aimed to compare the thickness of the asymptomatic plantar fascia between young, healthy pregnant women and nulliparous individuals, evaluating its relationship with age, body mass index (BMI), arch height index (AHI), gestational age, and number of pregnancies.

## MATERIALS AND METHODS

This cross-sectional study was conducted in Prof. Dr. R. D. Kandou Central General Hospital and Bahu Public Health Centre Manado, Indonesia between January and March 2023. The study was conducted in accordance with the Declaration of Helsinki and approval was obtained from the Health Research Ethics Committee of Prof. Dr. R. D. Kandou Central General Hospital (177/EC/KEPK-KANDOU/X/2022) and Manado Health Department (S2D.02/KES/SDK-LIT/III/2023). The Inform consents were obtained from all participants. This study included 300 feet, from 75 nulliparous, and 75 pregnant women who met the specified criteria. Based on the simple random samplin method, the inclusion criteria were subjects aged 18–35 years old and willing to participate in the study. Meanwhile, subjects with a history of foot pain, trauma, surgery, using special orthosis during pregnancy, and other complications were excluded.

Fascia thickness was measured with WISONIC Ultrasonic Diagnostic System Clover 60 using a 10 MHz linear array transducer. After the application of gel, measurements were taken 10 mm distal from the point of origin in the calcaneus [Figure 1]. Additionally, patient data such as age, height, weight, BMI, AHI, and parity profile, including gestational age and number of pregnancies, were duly recorded as part of the study.

AHI is a measurement method that is carried out to determine whether patients should be classified as high or low-arched.<sup>[10]</sup> This index is measured by dividing dorsum height of the foot at 50% of the total foot length with truncated foot length (length from the most posterior part of the calcaneus to the first metatarsophalangeal joint).<sup>[11]</sup> When the ratio is  $>0.356$ , the foot is classified as high arched, while  $<0.275$  shows low arched.<sup>[10]</sup>

Gestational age was measured with Naegele's Rule, which approximates the estimated delivery date based on the last menstrual period date. From this date, 1 year and 7 days were added, followed by subtracting 3 months to obtain the approximate age of the fetus.<sup>[12]</sup>

The average plantar fascia thickness, standard deviation, mean difference, and 95% confidence interval (CI) were assessed among nulliparous and pregnant women. The Student's *t*-test was used to assess significant differences among various groups. Pearson's correlation coefficients were used to determine correlations between plantar fascia and age, BMI, AHI, gestational age, and number of pregnancies. Significant

variables on bivariate analysis were subjected to multivariate logistic to estimate the coefficients of the linear equation and predict plantar fascia thickness.

## RESULTS

A total of 150 subjects were included in this study. The average nulliparous plantar fascia thickness was  $2.24 \pm 0.41$  mm (range: 1.60–3.60, CI: 2.15–2.33) and  $2.26 \pm 0.37$  mm (range: 1.60–3.40, CI: 2.18–2.35) on right and left foot respectively. Pregnant women showed an average plantar thickness of  $2.67 \pm 0.44$  mm (range: 2.00–4.10, CI: 2.58–2.77) and  $2.67 \pm 0.44$  mm (range: 1.80–4.00, CI: 2.57–2.77) on right and left foot, respectively, as presented Table 1.

After dividing the two populations based on BMI category (underweight, normal, overweight, obese), a substantial disparity in plantar fascia thickness on both feet was evident between nulliparous and pregnant women in each category ( $P < 0.05$ ), as shown in Table 2.

Plantar fascia thickness difference among pregnant women group was evaluated based on gestational age (1<sup>st</sup> trimester – 2<sup>nd</sup> trimester, 1<sup>st</sup> trimester – 3<sup>rd</sup> trimester) and number of pregnancies (1<sup>st</sup> pregnancy – 2<sup>nd</sup> pregnancy, 1<sup>st</sup> pregnancy – 3<sup>rd</sup> pregnancy, 1<sup>st</sup> pregnancy – 4<sup>th</sup> pregnancy). The results did not show any significant differences in plantar fascia thickness based on gestational age among pregnant women ( $P > 0.05$ ), as presented in Table 3. However, it was observed that pregnant women who experienced more than one pregnancy (multiparous) showed a significantly higher plantar fascia thickness ( $P < 0.05$ ), as shown in Table 4.

Among the nulliparous group, plantar fascia thickness was found to be correlated with age and BMI ( $P < 0.05$ ). As shown in Table 5, in pregnant women group there were correlations between plantar fascia thickness and age, BMI, with the number of pregnancies ( $P < 0.05$ ).

The results of the multivariate regression analysis showed that plantar fascia thickness was associated with age and BMI as predictor variables in nulliparous women. Meanwhile, plantar fascia thickness was associated with age, BMI, and number of pregnancies as predictor variables in pregnant women, as shown in Table 6.

## DISCUSSION

This study included a specific population, consisting of youthful nulliparous and pregnant women. The subjects were in the range of 18–35 years old with an average of  $26.09 \pm 3.89$  years on nulliparous and  $26.28 \pm 5.59$  years in pregnant women. This characteristic sets it apart from other similar studies comprising male and older populations.<sup>[1,7,13-16]</sup> However, no study has been conducted to evaluate plantar fascia thickness and its risk factors in nulliparous and pregnant women.

Plantar fascia thickness in nulliparous averaged  $2.24 \pm 0.41$  mm and  $2.26 \pm 0.37$  mm, while in pregnant women

**Table 1: Foot structure profile**

	Right plantar fascia			Left plantar fascia		
	Mean±SD	Range	95% CI	Mean±SD	Range	95% CI
Foot length (cm)						
Nulliparous	23.03±1.12	20.80–25.20	22.78–23.26	22.99±1.18	20.70–26.20	22.73–23.25
Pregnant	23.62±1.07	21.20–26.10	23.36–23.86	23.50±1.07	21.00–26.20	23.25–23.74
Truncated length (cm)						
Nulliparous	16.89±1.05	14.30–19.90	16.67–17.11	16.94±0.96	14.40–19.80	16.73–17.14
Pregnant	18.05±1.18	16.00–21.30	17.80–18.32	18.00±1.20	15.80–21.40	17.75–18.28
Dorsum height (cm)						
Nulliparous	5.99±0.36	5.20–7.00	5.91–6.08	5.98±0.33	5.10–7.00	5.90–6.05
Pregnant	6.05±0.41	5.10–7.00	5.95–6.13	6.02±0.45	4.90–7.10	5.91–6.11
AHI						
Nulliparous	0.355±0.029	0.30–0.44	0.35–0.36	0.353±0.025	0.30–0.47	0.34–0.35
Pregnant	0.335±0.022	0.27–0.42	0.33–0.34	0.335±0.025	0.25–0.43	0.33–0.34
PF thickness (mm)						
Nulliparous	2.24±0.41	1.60–3.60	2.15–2.33	2.26±0.37	1.60–3.40	2.18–2.35
Pregnant	2.67±0.44	2.00–4.10	2.58–2.77	2.67±0.44	1.80–4.00	2.57–2.77

AHI: Arch height index, SD: Standard deviation, CI: Confidence interval, PF: Plantar fascia

**Table 2: Asymptomatic plantar fascia thickness difference between nulliparous and pregnant women based on Asia Pacific body mass index category**

BMI category	n	Right plantar fascia (mm)				Left plantar fascia (mm)			
		Mean±SD	Mean difference	95% CI	P	Mean±SD	Mean difference	95% CI	P
Underweight									
Nulliparous	5	2.02±0.26	0.45	0.20–0.70	0.001	2.04±0.21	0.39	0.14–0.64	0.004
Pregnant	15	2.47±0.26				2.43±0.24			
Normal									
Nulliparous	37	2.14±0.29	0.51	0.34–0.66	<0.001	2.15±0.25	0.51	0.34–0.66	<0.001
Pregnant	43	2.65±0.40				2.66±0.42			
Overweight									
Nulliparous	14	2.25±0.45	0.70	0.20–1.20	0.008	2.31±0.41	0.62	0.20–1.06	0.007
Pregnant	9	2.95±0.70				2.93±0.60			
Obese									
Nulliparous	19	2.47±0.50	0.43	0.01–0.85	0.039	2.47±0.46	0.41	0.02–0.80	0.037
Pregnant	8	2.90±0.42				2.88±0.41			

SD: Standard deviation, CI: Confidence interval, BMI: Body mass index

**Table 3: Asymptomatic pregnant women plantar fascia thickness difference based on gestational age**

	n	Right plantar fascia (mm)				Left plantar fascia (mm)			
		Mean±SD	Mean difference	95% CI	P	Mean±SD	Mean difference	95% CI	P
1 <sup>st</sup> and 2 <sup>nd</sup> trimester									
1 <sup>st</sup> trimester	9	2.53±0.46	0.13	–0.23–0.50	0.461	2.54±0.53	0.02	–0.33–0.36	0.933
2 <sup>nd</sup> trimester	22	2.66±0.45				2.56±0.39			
1 <sup>st</sup> and 3 <sup>rd</sup> trimester									
1 <sup>st</sup> trimester	9	2.53±0.46	0.16	–0.15–0.49	0.297	2.54±0.53	0.21	–0.11–0.54	0.202
3 <sup>rd</sup> trimester	44	2.70±0.43				2.75±0.43			

SD: Standard deviation, CI: Confidence interval

at 2.67 ± 0.44 mm on the right and left foot, respectively. As compared to general asymptomatic females in Asia region, a study conducted by Khan and Shiekh<sup>[14]</sup> in North India population showed plantar fascia thickness in female subjects was 2.35 ± 0.59 mm. An average of 2.32 ± 0.35 mm was

reported by Dhakal *et al.*<sup>[7]</sup> in Nepal, while Siahaan *et al.*<sup>[17]</sup> in Indonesia obtained 2.55 ± 0.49 mm and 2.57 ± 0.45 mm on the right and left foot, respectively. In this study, a thicker plantar fascia was obtained in pregnant women group as compared to previous reports.

**Table 4: Asymptomatic pregnant women plantar fascia thickness difference based on number of pregnancies**

	n	Right plantar fascia (mm)				Left plantar fascia (mm)			
		Mean±SD	Mean difference	95% CI	P	Mean±SD	Mean difference	95% CI	P
1 <sup>st</sup> and 2 <sup>nd</sup> pregnancy									
1	25	2.38±0.27	0.28	0.11–0.44	0.001	2.36±0.26	0.29	0.10–0.47	0.003
2	30	2.66±0.31				2.65±0.38			
1 <sup>st</sup> and 3 <sup>rd</sup> pregnancy									
1	25	2.38±0.27	0.69	0.48–0.91	<0.001	2.36±0.26	0.76	0.55–0.94	<0.001
3	14	3.07±0.38				3.12±0.32			
1 <sup>st</sup> and 4 <sup>th</sup> pregnancy									
1	25	2.38±0.27	0.58	0.21–0.95	0.003	2.36±0.26	0.62	0.32–0.91	<0.001
4	6	2.96±0.75				2.98±0.48			

SD: Standard deviation, CI: Confidence interval

**Table 5: Pearson correlation of risk factors on asymptomatic plantar fascia thickness**

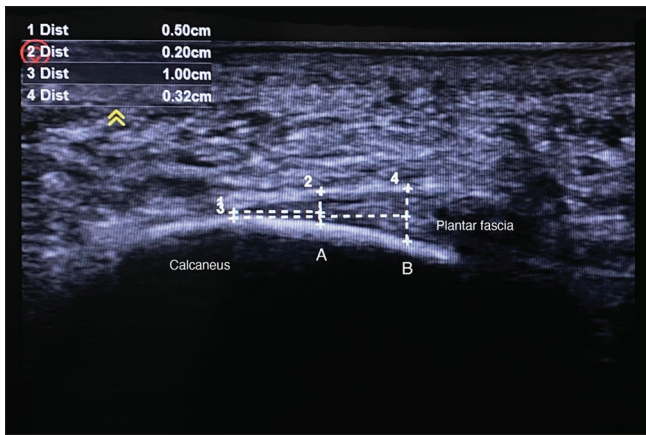
	Age	BMI	AHI	Gestational age	Number of pregnancy
Nulliparous					
Right plantar fascia					
Correlation coefficient (r)	0.278	0.376	0.185		
P	0.016*	0.001*	0.112		
Left plantar fascia					
Correlation coefficient (r)	0.258	0.316	0.154		
P	0.026*	<0.001*	0.186		
Pregnant					
Right plantar fascia					
Correlation coefficient (r)	0.273	0.326	-0.126	0.146	0.547
P	0.018*	0.004*	0.283	0.211	<0.001*
Left plantar fascia					
Correlation coefficient (r)	0.338	0.355	-0.135	0.228	0.588
P	0.003*	0.002*	0.247	0.149	<0.001*

\*Significant correlation at 0.05. BMI: Body mass index, AHI: Arch height index

**Table 6: Multivariate regression analysis of risk factors on asymptomatic plantar fascia thickness**

	B coefficient	r	r <sup>2</sup>	Adjusted r <sup>2</sup>	SE	Significant	P
Nulliparous							
Right plantar fascia							
Constant	0.799	0.446	0.199	0.177	0.368		<0.001*
Age	0.025					0.026	
BMI	0.034					0.001	
Left plantar fascia							
Constant	0.920	0.468	0.219	0.198	0.330		<0.001*
Age	0.021					0.042	
BMI	0.035					<0.001	
Pregnant							
Right plantar fascia							
Constant	1.756	0.587	0.344	0.316	0.363		<0.001*
Age	0.009					0.341	
BMI	0.029					0.040	
Number of pregnancy	0.268					<0.001	
Left plantar fascia							
Constant	0.1591	0.625	0.391	0.365	0.350		<0.001*
Age	0.004					0.646	
BMI	0.031					0.024	
Number of pregnancy	0.267					<0.001	

\*Significant correlation at 0.05. BMI: Body mass index, SE: Standard error



**Figure 1:** Plantar fascia measurement (A) at 5 mm distal from the point of origin in the calcaneus, (B) at 10 mm distal from the point of origin in the calcaneus

Pregnant women have a significantly thicker plantar fascia compared to nulliparous group when divided by BMI category. Some of the anatomical and physiological effects of foot structure during pregnancy included the weakening of ligaments due to elevated levels of the hormone relaxin, shifts in the body center of gravity, decrease in arch height, gradual increase in plantar pressure, and foot pronation, including changes in gait.<sup>[3,6,18-20]</sup> According to Ramachandra *et al.*,<sup>[18]</sup> reduction in arch height persisted for 6 weeks after delivery. This suggested that the structural changes in the foot occurring during pregnancy require an extended period to revert to the prepregnancy state after childbirth.<sup>[18]</sup> The combination of these factors, along with the repetitive traction of fascia during walking and weight-bearing activities, could contribute to microtears and degenerative processes, resulting in plantar fascia thickness.

Previous preliminary investigation expected that as pregnancy advances, pregnant women tend to show thicker plantar fascia. However, this study showed no significant difference in plantar fascia thickness when pregnant women were divided based on the gestational age. Varol *et al.*<sup>[21]</sup> reported that hormonal changes and alterations in the biomechanical structure of the body during pregnancy tend to peak in the final trimester. During this time, there is a significant decrease in the height of plantar arch, followed by an increase in both the length and width of the foot due to the progressive weight gain. According to Gijon-Nogueron *et al.*,<sup>[19]</sup> pregnant women often experience changes in the feet from the 12<sup>th</sup> to 34<sup>th</sup> week of gestation, characterized by foot widening and lengthening, along with increased pronation. Elevated relaxin levels in the final trimester also cause enhanced flexibility in the arch. This was accompanied by a simultaneous rise in weight during pregnancy can contribute to arch height reduction and foot pronation, potentially leading to increased plantar fascia thickness.<sup>[19]</sup> The discrepancy results obtained in this study are attributed to the presence of other biasing factors, such as age, BMI, and the number of pregnancies, which were not excluded when dividing pregnant women by gestational age. During comparison based on the number of pregnancies,

a significant difference was observed between the first pregnancy and any subsequent pregnancies. This was further explained by the report of Dunn *et al.*,<sup>[22]</sup> where women who experienced multiple pregnancies faced a higher exposure to hormone-weakening ligaments. Based on estimation, women with repeated pregnancies experienced higher exposure, potentially leading to more pronounced changes, particularly in terms of arch collapse and elevated BMI.<sup>[22]</sup>

Analyses conducted on asymptomatic nulliparous showed that age and BMI showed a statistically significant relationship and effect on plantar fascia thickness. The results were consistent with several other studies, indicating a connection between age, BMI, and the influence on plantar fascia thickness. Narindra *et al.*<sup>[13]</sup> and Abul *et al.*<sup>[16]</sup> reported a positive correlation between plantar fascia thickness and age, weight, height, and BMI. Similarly, Uzel *et al.*<sup>[23]</sup> found moderate correlations between plantar fascia thickness with weight and height. Siahaan *et al.*<sup>[17]</sup> suggested that age and BMI were the most influential risk factors for plantar fascia thickness. Khan and Shiekh,<sup>[14]</sup> Dhakal *et al.*<sup>[7]</sup> identified correlations between plantar fascia thickness with age, height, weight, and BMI. Generally, age is a risk factor for plantar fascia thickness as the cumulative impact of sustained and continuous biomechanical pressure on plantar fascia for numerous years can alter its thickness.<sup>[7]</sup> As individuals age increases, plantar fascia tends to thicken due to structural alterations in the heel, reduced collagen production, stiffening of the extracellular matrix, and increased fascial rigidity. These changes can result in a diminished ability to absorb vibrations in the foot and alter the biomechanical properties of the foot.<sup>[17]</sup> Van Leeuwen *et al.*<sup>[24]</sup> stated that increased plantar fascia thickness was a biological response to repeated stress, elongation, and deformation to the arch caused by high mechanical load from body weight.

Based on the analyses conducted on asymptomatic pregnant women, it was discovered that BMI and the number of pregnancies had a significant relationship, affecting plantar fascia thickness. A study on female guinea pigs by Dragoo *et al.*<sup>[25]</sup> showed that after 21 days of relaxin administration, there was a significant weakening of the anterior cruciate ligament during load testing in comparison to the control group. The results showed the potential impact of relaxin during pregnancy on ligament strength, contributing to the understanding of factors influencing plantar fascia thickness in pregnant women. Furthermore, it was expected that women with repeated pregnancies had greater exposure to the hormone relaxin, potentially leading to structural changes in the foot. Women with multiple pregnancies are also exposed to various other risk factors, including alterations in the body center of gravity, flattening of the arch, gradual increases in plantar pressure and pronation of the foot, as well as changes in gait. All of these factors collectively contribute to changes in plantar fascia thickness during pregnancy.<sup>[3,6,18,20]</sup>

## CONCLUSION

In conclusion, this study showed a significant difference in

plantar fascia thickness between nulliparous and pregnant women. Number of pregnancies seemed to be the most predictive factor of plantar fascia thickness in pregnant women. Consequently, screening and preventive measures should be implemented for pregnant women, specifically those with multiple pregnancies, to mitigate the risk of developing plantar fasciitis in the future.

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### Conflicts of interest

There are no conflicts of interest.

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