

# Thickness of the Plantar Fascia in Asymptomatic Subjects

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## Abstract

**Objectives:** The objectives of this study are to determine the average and extreme values of the thickness of plantar fascia (PF) and to evaluate its correlations with anthropometric parameters and walking activity. **Materials and Methods:** Analytic study of 226 feet. On these feet, the thickness of the PF was measured on ultrasound; and its correlation with the age, height, weight, body mass index (BMI), gender, and daily walking of the participants were studied. **Results:** Thickness of the PF was symmetrical; the extreme values were 1.8 mm and 4.3 mm with an average of 3 mm  $\pm$  0.5. There was positive correlation of PF thickness with age, height, weight, BMI, and daily walking ( $P < 0.05$ ). The variation of the PF thickness with gender was not significant ( $P > 0.05$ ). **Conclusion:** Thickness of PF has a close correlates with age, height, weight, BMI, and walking activity.

**Keywords:** Age, height, plantar fascia, ultrasound, walking activity, weight

## INTRODUCTION

The knowledge of the normal thickness of the plantar fascia (PF) is useful since the anomaly of this fibrous structure presents by a modification of the thickness. Even if the diagnosis of plantar fasciopathy is made on the basis of medical history and physical examination, medical imaging can be performed to assess the morphology of the PF and to eliminate certain pathologies such as plantar fibromatosis, rupture of the PF, plantar vein thrombosis, and muscular and neurogenic origin.<sup>[1,2]</sup> PF thickening to  $>4$  mm in ultrasonographic measurements can be accepted as meaningful in diagnoses of plantar fasciitis.<sup>[1]</sup> The insufficiency of published studies on this subject requires practitioners to refer to the opposite side while the condition could be bilateral and the values could also vary according to the morphotype of participants. Thus, we carried out an analytical study on the ultrasound measurement of PF thickness to determine the average and extreme values and to evaluate its variations according to the anthropometric parameters and the walking activity.

## MATERIALS AND METHODS

This was an analytical study conducted over a 6-month period involving 113 asymptomatic participants after

obtaining approval from University Hospital Review Board. Interrogation preceded sagittal ultrasound scan of the PF of all participants by the same examiner who has more than 5 years of experience in performing ultrasonography. The sonographic measurements of the thickness of the PF were performed using a TOSHIBA Aplio 400 machine with a 10 MHz linear probe. Participants with no notion of plantar pain or acquired or congenital deformities of the feet were included in this study. Participants with nodule of the PF were excluded from the study.

The parameters studied were age, gender, height, weight, body mass index (BMI), thickness of the median PF, its symmetry and its variation according to the walking activity. The walking activity was evaluated by questioning the participants about the distance traveled in kilometers per day on foot for work or school. Student's *t*-test was used to assess significant differences within group. Pearson correlation coefficients were used to determine correlations between PF and anthropometric parameters. Multivariate regression analysis was performed to

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estimate the coefficients of the linear equation.  $P < 0.05$  was considered statistically significant.

## RESULTS

The study population consisted of 82 women (72.6%) and 31 men (27.4%). Subject mean age was  $33.05 \pm 5.4$  years. The mean weight was  $50.57 \pm 4.2$  kg and the mean height was  $150 \pm 15.2$  cm. Participants were rated as underweight ( $15 < \text{BMI} < 19.9$ ) (7%), normal weight ( $20 < \text{BMI} < 24.9$ ) (73%), overweight ( $25 < \text{BMI} < 29.9$ ) (15%), and obese ( $\text{BMI} > 30$ ) (5%) based on calculated BMI.<sup>[3]</sup> Eighteen point 6% (21 patients) traveled  $< 5$  km per day, 54.9% (62) between 5 and 10 km and 26.5% (30)  $> 10$  km. Figure 1 shows the measurement site of the thickness of the PF. Extreme values of PF thickness of the right foot were 1.8 mm and 4.3 mm with an average of  $3.02 \text{ mm} \pm 0.54$  and a median of 3.10 mm ( $P < 0.05$ ). These extreme values were 1.9 mm and 4.1 mm with an average of  $3.04 \text{ mm} \pm 0.49$  and a median of 3.10 mm for the left side ( $P < 0.05$ ). The thickness of the PF was symmetrical in 90.3% of cases ( $P < 0.05$ ,  $r = 0.83$ ).

The thickness of PF varied according to the subject age ( $P < 0.05$ ,  $r = 0.17$ ). The correlation function was written as follows:

PF at right or left in mm =  $0.010 \times \text{age in years} + 2.7$ .

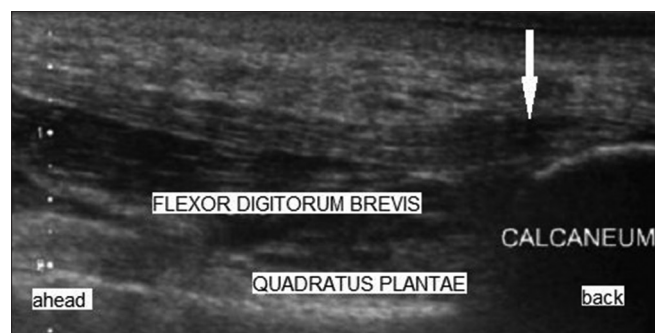
There was a statistically positive variation in PF thickness at right and left side as a function of subject height ( $P < 0.05$ ,  $r = 0.37$ ). The correlation function was written as follows:

PF at the insertion at right or left in mm =  $0.014 \times \text{height in cm} + 0.8$

PF thickness varied according to the weight of participants at right and left ( $P < 0.05$ ,  $r = 0.35$ ). The correlation function was written as follows:

PF at the insertion at right or left in mm =  $0.019 \times \text{weight in kg} + 1.9$

The thickness of the PF correlated with BMI ( $P < 0.05$ ) and the mean ranged from 2.5 mm at insertion for underweight to 3.8 mm for obese patients; 2.9 mm for normal weight and 3.3 mm for overweight.



**Figure 1:** Sagittal sonographic image of the plantar fascia showing the site where the measurement of the thickness was performed (arrow)

There was no statistically significant difference in PF thickness values given by correlation functions for age, height, and weight ( $P < 0.05$ ).

The variation of the PF thickness as function of gender was not statistically significant at right and left ( $P > 0.05$ ).

The thickness of the PF at right and left varied according to the importance of walking activity ( $P < 0.05$ ). Participants (100%) who had completed more than 10 km per day had PF thickness at left and right greater than 3 mm; 61.29% of the left feet (38 of 62) and 56.45% of the right feet (35 of 62) of participants that had walking daily between 5 and 10 km had PF thickness  $> 3$  mm; the remaining 38.70% (24 of 62) of the left feet and 43.53% (27 of 62) of right feet had PF thickness  $< 3$  mm. For those who traveled  $< 5$  km per day, 90.5% had PF thickness  $< 3$  mm at right and left and 9.5%  $> 3$  mm at right and left.

## DISCUSSION

This study included a fairly large population with extreme ages of 5 years and 75 years compared to Pascual Huerta and Alarcón García,<sup>[4]</sup> who studied 48 patients with no age specification; however, the ratio between men and women was similar for both studies (2.6/1 and 2/1). The average thickness of PF was  $3.02 \pm 0.54$  mm on the right and  $3.04 \pm 0.49$  mm on the left, and the extreme values rarely exceeded 4 mm. The thickness of the PF gradually decreased away from the insertion toward ahead.

There was a very good correlation between PF thickness at right and left and age of participants. It has been shown that the foot with its anatomical components follows a relatively accelerated growth rate during the first two decades of life;<sup>[5]</sup> this was found in this study with a clear increase in the thickness of the PF between 5 and 20 years. In addition, League has suggested that advanced age is one of the risk factors for thickening and inflammation of PF.<sup>[6]</sup>

This study found a statistically significant variation of PF thickness at right and left according to the subject height. According to Bonnel, high height participants have rather large anatomical structures and the foot follows a parallel growth even relatively accelerated compared to the height of the subject with a proportion of the order of 44% at 1 year old.<sup>[5]</sup>

There was a statistically significant variation of the thickness of the PF according to the weight of the participants at right and left, but with a correlation intensity that is weaker than that for height, but stronger than that for age. Some authors have deduced that for obese or overweight patients, plantar pressure is higher when standing or walking than normal participants;<sup>[7,8]</sup> while this plantar overpressure participates in a hyper-solicitation at the origin of micro traumatism of the sole of the foot which participate in the thickening of the PF.<sup>[4,9-11]</sup>

In our study, the BMI also participated as a factor favoring the thickening of PF. On the other hand, the thickness of the

PF at the right and at the left side did not vary according to the gender of the participants as found by Gadalla *et al.*<sup>[12]</sup> while Pascual Huerta and Alarcón García found a variation in the thickness of the PF measured at its insertion and at 1 cm distally according to gender and that he considered related to the difference of certain fibers that would be thicker in men than in women, and he concluded that the thickness of PF in men exceeds 0.42 mm that of women.<sup>[4]</sup> The thickness of the PF at right and left was symmetrical in 90.3%. We believe that the few asymmetric values would be partly related to a measurement error since the difference did not exceed 0.20 mm. This symmetry was also found by Gadalla *et al.*<sup>[12]</sup> This symmetry is preserved even if the thickness of the PF decreases progressively away distally from the insertion. According to the walking activity, the thickness of the PF increased as a function of the daily distance traveled. Mechanical and sporting constraints of the foot contribute mainly to the thickening of the PF and secondarily to its deterioration and chronic inflammation.<sup>[6,13-15]</sup> League<sup>[6]</sup> mentioned that even a simple daily activity, of which he did not specify the type, can cause the thickening of the PF. In this study, we concluded that daily walking activity contributes proportionately and inevitably to the thickening of PF.

## CONCLUSION

Ultrasound using high-frequency transducers is an imaging technique for measuring PF thickness. The average thickness of the PF at insertion is 3 mm  $\pm$  0.5 and progressively decreases forward. Extreme values rarely exceed 4 mm. The thickness of PF has a close correlates with age, height-weight, and BMI and remains symmetrical notably at the level of its calcaneal insertion. On the other hand, no statistical relation could be established between PF thickness and gender. The walking activity contributes to the thickening of the PF. In sum, findings for PF in this study are valuable in diagnosing PF pathology in different age populations.

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## Conflicts of interest

There are no conflicts of interest.

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