ÖZGÜN ARAŞTIRMA ORIGINAL RESEARCH

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EVALUATION OF THE ELASTICITY AND THICKNESS OF THE HEEL FAT PAD WITH ULTRASOUND IN PLANTAR FASCIITIS

PLANTAR FASİİTTE TOPUK FAT PAD ELASTİKİYETİNİN VE KALINLIĞININ ULTRASON İLE DEĞERLENDİRİLMESİ

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Öz

Amaç
Bu çalışmanın amacı, tek taraflı plantar fasiitli hastalarda topuk yağ yastığının kalınlığını ve elastikiyetini değerlendirmek ve yaş, cinsiyet, vücut kitle indeksi (VKİ) ve fonksiyonel skorların plantar fasiit üzerindeki etkilerini araştırmaktır.

Gereç ve Yöntem
Çalışmaya 6 aydan uzun süredir tek taraflı plantar fasiiti olan toplam 70 hasta dahil edildi. Hastaların ağrılı ve sağlıklı ayakları arasında ultrason ile yağ yastığının kalınlığı ve elastikiyeti karşılaştırıldı. Elastisite ölçümü için Shear Wave Elastografi (SWE) kullanıldı. Fonksiyonel değerlendirme American Orthopaedic Foot and Ankle Society Skoru (AOFAS) ile yapıldı. Ağrılı ve sağlıklı taraflar arasında kalınlık ve elastikiyet değişkenleri, bağımsız grup t-testi ve Mann-Whitney U testi kullanılarak karşılaştırıldı.

Bulgular
Hastaların yaş ortalaması 44±11.66 idi. Topuk yağ yastığının ortalama kalınlığı etkilenen tarafta 17.9±3.1 mm ve sağlıklı tarafta 18.3±3.3 mm idi. Ağrılı tarafta ortalama SWE değeri 23.9 m/s (9.3-32), sağlıklı tarafta 24.7 m/s (10.8-34) idi. Hastaların ortalama AOFAS skoru 70 (62-78) idi. Topuk yağ yastığı kalınlığı, sağlıklı ayaklarda ağrılı ayaklara göre daha fazlaydı, ancak bu fark istatistiksel olarak anlamlı değildi (p=0,448). Ağrılı ayaklar daha sertti, ancak fark istatistiksel olarak benzerdi (p=0,347). Ağrılı ve sağlıklı ayaklar arasındaki elastikiyet ve kalınlık değerleri cinsiyetten etkilenmemiştir. VKİ, ağrılı ve sağlıklı ayaklar arasındaki topuk yağ yastığı kalınlığı üzerinde istatistiksel olarak anlamlı bir etkiye sahiptir.

Sonuç
Topuk yağ yastığı kalınlığındaki azalma plantar fasiit için, VKİ normal olan hastalarda destekleyici bir bulgudur ancak VKİ>25 olan hastalarda destekleyici değildir.

Anahtar Kelimeler: Elastisite, Fat pad, Plantar fasiit, Shear wave elastografi

Abstract

Objective
The aim of this study was to evaluate thickness and elasticity of heel fat pad in patients with unilateral plantar fasciitis and to investigate the effects of age,

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sex, body mass index (BMI), and functional scores on plantar fasciitis.

Material and Method
70 patients who had been suffering from unilateral plantar fasciitis longer than 6 months were enrolled in the study. The thickness and elasticity of fat pad were compared between the painful and healthy feet of the patients with ultrasound. For measurement of elasticity, shear wave elastography (SWE) was used. Comparative analysis was performed for thickness and elasticity variables between the painful and healthy feet with Mann–Whitney U and independent samples t-test.

Results
Average of age of the patients was 44±11.66. The average thickness of the heel fat pad was 17.9±3.1 mm on the affected side and 18.3±3.3 mm on the healthy side. The mean SWE value of the painful side was 23.9 m/s (range 9.3-32) and was 24.7 m/s (range 10.8-34) on the healthy side. Heel fat pad thickness was greater in the healthy feet than in the painful feet, but there was no statistical significance (p=0.448). The painful feet were stiffer, but the difference was statistically similar (p=0.347). BMI had a statistically significant impact on thickness of heel fat pad.

Conclusion
The results showed that a decrease in the heel fat pad thickness was a supporting finding of plantar fasciitis in patients with normal BMI but not in patients with BMI>25.

Keywords: Elasticity, Fat pad, Plantar fasciitis, Shear wave elastography

Introduction

Plantar fasciitis is a common cause of foot pain (1). The most affected age group is 40-60 and in the general population lifetime prevalence is projected to be 10% (2, 3). During normal gait, the heel fat pad is affected by approximately 20%-25% of the contact loads of the heel in stance and off phases (4). There are studies in the literature evaluating the roles of the mechanical attitudes of the plantar fascia and heel fat pad on plantar pain, and biomechanical alterations are mostly blamed (5, 6). Risk factors for plantar fasciitis are acute inflammation, excessive prolonged standing or running, and degenerations and alignment pathologies of the foot (7, 8). Persistent overloading and degeneration lead to disruption of collagen repair and regeneration processes of the plantar fascia, and cause fibrosis and thickening (9). Increase in the thickness of the plantar fascia leads to decrease in elasticity and regression in capacity for shock absorption (7). Physical examination and medical history of the patients are mostly sufficient for diagnosing plantar fasciitis. Radiological imaging is used in order to clarify the diagnosis in patients with persistent heel pain (10). Changes and abnormalities of soft tissue components can be detected by ultrasonography (USG). USG is a cheap and an easy method to detect the pathologies in plantar fascia. Hypoechogenicity and thickened plantar fascia detected by USG have diagnostic value (11, 12). Thickness of plantar fascia >4 mm is accepted as diagnostic for plantar fasciitis. The dynamic stability of the foot and ankle is affected by muscles, ligaments, and fascia, and the elastic properties of these tissues are of major importance (13). The biomechanical effects of the thickness and elasticity of the heel fat pad have not been clarified yet. The aim of the present study was to compare the thickness and elasticity of the heel fat pad in patients with unilateral heel pain. It was hypothesized that heel fat pad thickness and elasticity play a role in the diagnosis of plantar fasciitis, and it is affected by age and body mass index (BMI).

Material and Method

Patients and Methods

After obtaining institutional ethical committee approval and measurements were performed following informed consent (Izmir University of Economics Ethical committee, Date: 02.03.2021, No: B.30.2.İEÜSB.0.05.05-20-114). A total of 70 patients were included in our prospectively designed study. Patients with unilateral plantar fasciitis that presented with pain on the first steps in the morning and regressed with rest and having complaints for longer than 6 months were investigated. Thickness of plantar fascia >4 mm on the affected side was accepted as diagnostic for plantar fasciitis. Patients who underwent foot or ankle operations, patients who had steroid injections or shock wave therapy, patients with neuromuscular disease, patients with rheumatologic disease, patients with malignancies, pregnant or breastfeeding patients, and patients who had acute trauma were excluded from the study. Data regarding age, sex, weight, height, and BMI were collected. Pain and disability were assessed through questionnaires and scores of the American Orthopaedic Foot and Ankle Society (AOFAS). Both feet of the patients were evaluated radiologically and the differences between the feet with and without heel pain were compared.

Measurement Technique

All the measurements were performed by one radiologist in a blinded fashion. The assessments were performed bilaterally without clinical details. During the measurements the radiologist was not allowed to ask about pain. After the patient was positioned prone on the examination table, both heels were divided into three equal parts in the sagittal plane. Measurements were made at the center mark. In order to avoid loading compression during measurements, all patients were examined in the prone position and the foot was fixed in 90 degree position, the ultrasound probe was fixed to a portable stand, and the probe was used without compression (Figure 1, 2). The measurements were repeated twice in order to provide intrarater

Figure 1
The patient was in the prone position with the foot fixed at 90 degrees. The ultrasound probe was fixed to a portable stand and measurements were performed without load compression.

reliability. Ultrasound-based shear wave elastography was performed in all patients with the Aplio 500 series ultrasound system and Acoustic Structure QuantificationTM (ASQ) software by Toshiba (Figure 3). This system enables real-time visualization of a color quantitative elastogram superimposed on a grayscale image. The heel fat pad shear wave speed was assessed with a linear array probe of 8–12 MHz. The region of interest (10 mm × 10 mm square) was positioned in the heel fat pad (not including other structures as much as possible). The ultrasound main axis was set parallel to the foot's long axis. In all patients, 2 different ASQ shear wave elastography sequences were aimed and 8 measurements from different parts of the range of interest box were collected. The median value was calculated, and the result was expressed in meters/second (m/s). The measurements were repeated twice and average measurements were noted.

Figure 2
Ultrasonographic image showing the measurement of the thickness of the heel pad.

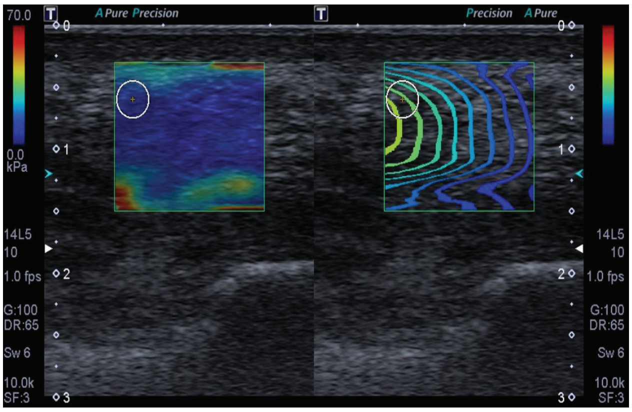

Figure 3
Ultrasonographic image showing the measurement of heel fat pad elasticity with shear wave elastography.

Statistical Analysis

For statistical analyses IBM SPSS Statistics 25.0 (IBM Corp., Armonk, New York, USA) was used. The normality of distribution of the data of continuous variables was evaluated with the Shapiro–Wilk test and Q–Q plots. Descriptive statistics were given as frequency (n), percent (%), median (M), 25th percentile (Q1), 75th percentile (Q3), mean, and standard deviation values. Fat pad thickness and elasticity variables were compared between the painful and healthy side groups with the independent samples t-test and Mann–Whitney U test. The relations of the healthy and painful side groups with age, sex, and BMI were also evaluated with the independent samples t-test and Mann–Whitney U test. Patients with BMI>25 were compared with those with normal BMI (18.5-24.9). The factors affecting the painful side were investigated by logistic regression analysis. Odds ratio (OR) and 95% confidence intervals were stated. A value of $p<0.05$ was considered statistically significant.

Results

The average of the age of the patients was 44±11.66 (range 25-75). While 62.9% of the patients were female, 37.1% were male. The left foot was more commonly affected [41(58.6%) patients left; 29 (41.4%) patients right]. The average height was 1.70 m (range 1.56-1.86), the mean weight was 78.3 kg (range 55-100), and mean BMI was 27.1 kg/m2 (range 21.5-36.7) and was similar between the sexes. The average AOFAS score of the patients was 70 (range 62-78). The mean thickness of the heel fat pad was 17.9±3.1 mm in the feet with pain and 18.3±3.3 mm in the feet without pain. The mean SWE value of the affected feet was 23.9 m/s (range 9.3-32) and was 24.7 m/s (range 10.8-34) in the unaffected feet. Heel fat pad thickness was greater in the healthy feet than in the painful feet, was statistically not different (p=0.448). The painful feet had lower elasticity values, but the difference was statistically similar (p=0.347). The elasticity and thickness values between the painful and healthy feet were not affected by sex. Moreover, no significant impact of age was found in the elasticity or thickness values between the groups. BMI had a statistically significant impact on heel fat pad thickness between the painful and healthy feet ($p<0.05$). The thickness of the heel fat pad on the painful side was significantly lower among patients with normal BMI when compared with overweight and obese patients ($p<0.05$) (Table 1-3). In the regression model, fat pad thickness and elastic variables were found not to be affecting functional scores.

Table 1 Effect of body mass index on the thickness and elasticity of the fat pad of the painful and healthy sides

	<25 n=20	≥25 n=50	Test statistics	p value
Thickness of painfull side (mm)	16,66±2,94	18,50±3,21	-2,266	**0,027¥***
Thickness of healthy side (mm)	17,14±2,90	18,89±3,39	-2,028	**0,046¥***
Elasticity of painfull side (m/s)	21,60±7,18	24,80±5,17	-1,503	0,113€
Elasticity of healthy side (m/s)	22,94±6,64	25,45±5,38	-1,574	0,116€

*p<0,05 ¥ Student's t-test € Mann Whitney-U test

Table 2 Effect of sex on the thickness and elasticity of the fat pad of the painful and healthy sides

	Male n=26	Female n=44	Test statistics	p
Thickness of painfull side (mm)	18,33±3,29	17,76±3,10	0,724	0,472¥
Thickness of healthy side (mm)	19,0±3,33	18,03±3,32	1,168	0,247¥
Elasticity of painfull side (m/s)	25,16±4,79	23,13±6,45	-0,906	0,365 €
Elasticity of healthy side (m/s)	25,89±4,85	24,04±6,29	1,286	0,203¥

*p<0,05 ¥ Student's t-test € Mann Whitney-U test

Table 3 Relations between age variable thickness and elasticity of fat pad of painful and healthy sides

n=70		Age	Thickness of painfull side (mm)	Thickness of healthy side (mm)	Elasticity of painfull side (m/s)
Thickness of painfull side (mm)	r	0,159			
	p	0,187			
Thickness of healthy side (mm)	r	0,113	,929**		
	p	0,352	0,001		
Elasticity of painfull side (m/s)	r	0,058	0,117	0,126	
	p	0,636	0,333	0,298	
Elasticity of healthy side (m/s)	r	0,039	0,169	0,194	,877**
	p	0,750	0,161	0,108	0,001

*p<0,05 **p<0,01

Discussion

Changes in the thickness and the biomechanics of the heel fat pad in plantar fasciitis have been studied in the literature. We compared in our study group the thickness and elasticity of the heel fat pad of healthy and painful feet of patients that had unilateral plantar fasciitis. The heel fat pad was thinner on the painful side but the difference was not significant. We observed that the changes in the thickness of the heel fat pad was a supporting finding in patients with normal BMI but not in overweight and obese patients.

Turgut et al. revealed in their studies that the thickness of the heel fat pad was not significantly different between opposite sides in patients with unilateral heel pain (14). In the study by Belhan et al. the heel fat pad was significantly thinner on the affected side in patients with unilateral plantar fasciitis (7). The factors that may affect the thickness of the heel fat pad in plantar fasciitis were investigated in our study. The role of sex, age, and BMI was examined. Only changes in BMI were found to be affecting the thickness of the heel fat pad significantly in plantar fasciitis ($p<0.05$). Thickness on painful side was significantly lower among patients with normal BMI (18.5-24.9). Thickness was also lower among patients with BMI>25 but the difference was not significant. The effect of BMI on plantar fasciitis was investigated in the literature widely. Increased weight and BMI were accepted as risk factors for plantar fasciitis, but the mechanism was still unclear. In one study thickness of the heel fat pad values were similar between obese and non-obese patients (7).

The role of sex in plantar fasciitis was evaluated previously in studies. Plantar fasciitis was reported to be more common among females. In the present study the majority of the patients were female. Sex was not found to be affecting the thickness of the heel fat pad in plantar fasciitis. This finding was consistent with the previous studies (4, 7). Increase in age was reported to affect the thickness of the heel fat pad in the literature. Thickness was reported to be increasing with increased age (15). We observed in our study group that age does not affect the thickness of the heel fat pad significantly. This finding was not concordant with the literature. We thought that the relatively young age of our patients may have been the reason for this. We also compared the elasticity of healthy and painful sides in plantar fasciitis. Changes in the elasticity of the plantar fascia and heel fat pad have been investigated widely in the literature. Measurements were performed previously with changes in X-ray and real-time USG. Recently SWE has been used for detecting changes in elasticity. Before SWE, differences in elasticity were compared using techniques that needed active compression. With the help of SWE, measuring elasticity without compression has become possible. SWE enables elasticity values to be assessed more sensitively and homogenously. We tried to avoid compression in our study. A portable stand was used for the measurements of elasticity values by SWE.

We evaluated the difference in elasticity and possible related factors between affected and healthy feet. We observed in our patient group that elasticity of the heel pad was lower on the affected side, but the difference was not statistically significant (p=0.347). In the study by Turgut et al. a comparison of stiffness of the heel fat pad was performed between patients with plantar heel pain and healthy individuals (14). They showed that elasticity was not significantly different in patients with plantar heel pain. In another radiological study stiffness of the heel fat pad was compared between patients who had unilateral or bilateral heel pain and healthy subjects (16). No significant difference was found in that study regarding stiffness of the heel fat pad in heel pain. Sconfienza et al. conducted a study in 2013 that evaluated the elasticity of plantar fascia in patients with plantar fasciitis (17). They compared patients with plantar fasciitis and patients that were asymptomatic. Measurements were performed with B-mode USG. They reported that stiffness in patients with plantar fasciitis was significantly higher (p<0.001).

Heel fat pad elasticity was evaluated with SWE in the study by Lin et al. in patients with heel pain (18). They compared the elasticity between both heels of 16 patients with unilateral heel pain and 20 participants without heel pain. They revealed that plantar heel pain was associated significantly with stiffness of the heel fat pad. We found in our study with SWE that the stiffness was greater on the side with plantar fasciitis but the difference was not significant. Our patient group all had complaints for longer than 6 months. Our patient group was not homogeneous regarding age or functional capability. We thought that this might have influenced this difference.

The factors that may be related to the elasticity of the heel fat pad were also evaluated in our study. Elasticity of the heel fat pad measured by SWE was not affected by sex in healthy and painful feet in the present study. Prichasuk et al. published a study performed with 400 healthy feet (19). In their study sex has no impact on the elasticity of the heel pad. Increased stiffness with age was reported previously in the literature (14, 15, 17). In our patient group elasticity tended to decrease with age. The effect of obesity on the elasticity of the heel fat pad is a subject of debate. An increase in weight was thought by some authors to be a factor increasing fat pad volume but some authors thought that increased weight may cause degeneration and atrophy of the fat pad. We did not observe any significant changes in the elasticity of the heel fat pad regarding BMI. In the literature it was reported that an increase in weight is related with increased stiffness (14, 19, 20). Measurements of elasticity were performed by SWE in our study and the present study was among the few studies evaluating the factors responsible for changes in elasticity with SWE in plantar fasciitis. The difference in the results may have been due to this.

In recent studies the prognostic value of imaging has been evaluated and the efficiency of USG assessed in evaluating clinical response after treatments in plantar fasciitis. In the study by Ermutlu et al. the effect of the thickness of the plantar fascia on the outcomes of two treatment modalities was evaluated (21). They investigated 70 patients diagnosed with plantar fasciitis, treated by corticosteroid injection or extracorporeal shock wave therapy (ESWT). The AOFAS scores of the patients were improved after treatment. They reported that measurement of the thickness of the plantar fascia did not have prognostic value. Lai et al. conducted a study similarly comparing the outcomes of corticosteroid injection and ESWT for chronic plantar fasciitis (22). The thickness of the plantar fascia of the patients was measured by USG and visual analogue scale (VAS) scores were recorded before treatments. It was reported that pretreatment thickness of the plantar fascia showed no association with VAS scores. We also investigated the relation of AOFAS score with changes in the elasticity and thickness of the heel fat pad. A thinner fat pad and loss of elasticity showed no association with AOFAS scores. We also observed in patients with thickness of plantar fascia >4 mm that an increase in the stiffness of the heel fat pad had no significant effect on AOFAS scores.

The present study has some limitations. First, the study did not have a control group. Second, there were a limited number of patients in the study. Although the measurements of USG were performed by a radiologist experienced in musculoskeletal imaging, the measurements were performed by only one radiologist. Another limitation of the study is that the measurements were not compared with load compression. We are also aware that the measurements in our study were static and static radiological measurements could not demonstrate sufficiently the dynamic functions of the foot.

USG is widely used for radiological imaging in pathologies of the plantar fascia. It is an efficient, cheap, quick, and easy method of imaging in plantar fasciitis. Measurement of the thickness of the plantar fascia and determining heterogeneities are supportive findings. In the present study a decrease in the thickness of the heel fat pad was a supporting finding of plantar fasciitis in patients with normal BMI but not in patients with BMI>25.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Ethical Approval

Izmir University of Economics Ethical committee approved the study (Date: 02.03.2021, No: B.30.2.İEÜSB.0.05.05-20-114). The study was conducted in line with the principles of the Helsinki Declaration.

Consent to Participate and Publish

Written informed consent to participate and publish was obtained from all individual participants included in the study.

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Availability of Data and Materials

Data subject to third party restrictions.

Authors Contributions

All authors meet the criteria for authorship. Conception=ÇB,UMY; Design=ÇB; Acquisition of data=ÇB,UMY,MÜ; Analysis and interpretation of data=ÇB,UMY,MÜ; Writing=ÇB; Drafting the article: ÇB,UMY,MÜ; Revising the article critically for intellectual content=ÇB,UMY,MÜ.

Editorial

Although MÜ, one of the authors of the article, is editorial board member of the journal, he has not taken part in any stage of the publication processes of this article.

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