Original Research Article

Relationship Between Subcalcaneal Fat Pad Thickness And Plantar Heel Pain: A Case Control Study

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Abstract

Background: Heel pain is common in active young and old adults. Plantar pain usually develops due to degeneration of heel fat pad. Loss of elasticity and changes in thickness of fat pad are considered to cause plantar heel pain.

Objectives:

1. To compare sub calcaneal fat pad thickness and its compressibility between the patients with and without current plantar heel pain.
2. To assess correlation of heel pad parameters with age and BMI.

Materials and Methods: A case control study was conducted in the Department of orthopaedics at Raja Rajeswari Medical College and Hospital. Heel pad compressibility index, heel pad thickness in loading (HPTL), heel pad thickness in unloading (HPTUL) were considered as primary outcome variables and demographic variables, anthropometric variables, were considered as Study relevant parameters. Heel Pain was considered as Primary explanatory variable.

Results: There was significant difference in the median values of heel pad parameters between cases and controls (HPCI:0.85 v/s 0.66, HPTL: 12.00 v/s 11.25, HPTUL:15.00 v/s 18.00, *p*<0.001). Among cases, age showed positive correlation with HPCI and HPTL with a r value of 0.26, 0.18 respectively (*p*<0.0%). BMI showed positive correlation with

HPTUL with a r value of 0.22 (p<0.05). Heel pad parameters failed to show correlation with age and BMI except that BMI showed negative correlation (r=-0.32, p<0.05) with HPCI among controls.

Conclusion: The findings of the study showed difference in heel fat pad thickness and elasticity between participants with and without heel pain. Age and body mass index showed positive correlation with heel pad parameters which indicates that increase in thickness of heel fat pad is one of the causes of heel pain.

Keywords: Plantar heel pain, heel pad thickness, compressibility index, age, BMI, correlation, case-control study

Introduction

Foot problems prevalence is increasing in recent years and they are difficult to manage because of their multifactorial aetiology. Most of the foot problems including plantar heel pain poses difficulty in establishing the major cause of the problem. This makes the problem chronic and causes huge burden on the individual [1]. Advancing age and female gender are usually associated with foot pain [2]. Chronic pain is one of the most disabling problems which will have significant health, social and economic burden. Musculo-skeletal pain causes loss of 2462 disability adjusted life years per 100,000 population and is ranked second highest cause of disability [3]. The reduction in health-related quality of life will be more pronounced when the pain is chronic and is of high intensity [4]. Plantar heel pain is considered as the most common Musculo skeletal condition of lower limb affecting both active and sedentary individuals [5]. It is estimated that plantar heel pain affects around one million population world-wide per year [6]. Plantar pain usually develops due to degeneration of heel fat pad. The heel fat pad helps in shock absorption. Loss of elasticity and changes in thickness of fat pad are considered to cause plantar heel pai [7]. The aetiology of plantar heel pain is considered as multifactorial including foot level factors such as pronated foot type [8], limited ankle joint dorsiflexion [9], first metatarsophalangeal joint dorsiflexion [10], reduced muscle strength, increased body mass index, depression, anxiety and stress [11], occupations requiring prolonged standing. Plantar heel pain can put considerable burden on the individuals, their families and society as a whole [12].

Objectives

1. To compare sub calcaneal fat pad thickness and its compressibility between the patients with and without current plantar heel pain.
2. To assess correlation of heel pad parameters with age and BMI.

Methodology

A case-control study was conducted in the Department of orthopaedics at Raja Rajeswari medical college and hospital among eligible subjects in 25 to 60 years age group attending OPD with heel pain for a period of 1½ year (January 2021 to July 2022).

Sample size: Was calculated by using Yamane equation. n= N/1+N(e)2, Where n = the sample size, N = the population size, e = 0.05, the acceptable sampling error for 95% confidence interval, considering 3.2 cases per week as per hospital statistics, N=166 and therefore n=120. Including 60 controls, the total sample size was 180 (cases-120, control-60). Sampling method followed in the study was convenient sampling.

Inclusion criteria

- Patients between age 25-60 years of both sexes attending ortho OPD with heel pain and who have given consent.

Exclusion criteria

Neurologic causes, Arthritic causes, Traumatic causes, Bone tumours of foot, Rigid flat feet, previously operated calcaneal fracture, Diabetes mellitus, Calcaneal spur.
Two groups of patients are included:

- **First group:** Patients with heel pain.
- **Second group:** Patients without heel pain.

Method of collection of data

After approval of Ethical clearance from Institutional Human Ethics Committee, informed written consent was obtained from all the study participants. All the relevant parameters were collected using a structured study proforma. Lateral view x- ray images were obtained from the cases.

Body Mass Index [13]: It was calculated for both cases and controls

Method of X-ray procedure: Lateral radiograph of both the feet was taken loaded and unloaded by body weight, with a tube film distance of 40 inches and the thickness of soft tissue shadow beneath the calcaneum was measured along a perpendicular line from the lowest part of plantar tuberosity to the skin edge [14] (Figure-1)

Heel-pad compressibility index (HPCI): The ratio of thickness in loaded and unloaded position was the definition for HPCI. Average thickness of both the feet was considered for HPCI calculation in both cases and controls. An HPCI index approaching 1 indicated a lack of elasticity of heel pad (Figure-2).

Compressibility index: DICOM images were used as source (which had PPI information) for the calculation of length in the image field below the plantar tuberosity of calcaneum to the skin edge. Ratio of the measurements obtained was the compressibility index (Figure-2).

Fig 1: Lateral radiograph of the foot in loaded (A) and unloaded (B) by body weight

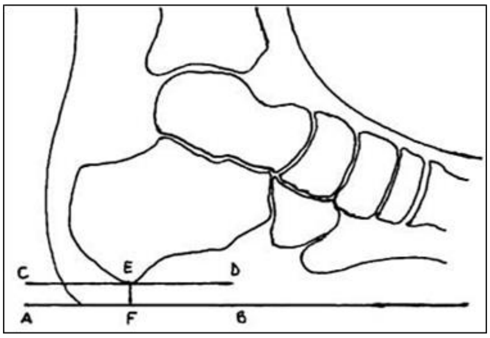


Fig 2: Heel pad measured at shortest distance between calcaneus and plantar surface of the skin (EF). AB = the skin line; CD = the longest part of the plantar tuberosity of the calcaneus

Statistical analysis

Descriptive analysis was carried out by mean and standard deviation for quantitative variables, frequency and proportion for categorical variables. For normally distributed Quantitative parameters the mean values were compared using Independent sample t-test. For non-normally distributed Quantitative parameters, Medians and Interquartile range (IQR) were compared between study groups using Mann Whitney u test. Categorical outcomes were compared between study groups using Chi square test. Correaltion of heel pad parameters was done using Spearman correlation test. P value < 0.05 was considered statistically significant. Data was analyzed by using coGuide software, V.1.01.

Results

Mean age was 43.97 ± 9.50 (years) in the cases and 39.82 ± 11.22 (years) in the controls. The mean difference in age between cases and controls was statistically significant (P value 0.0102). The difference in the gender distribution between cases and controls was found to be insignificant with majority of 62 (51.67%) male participants, 58 (48.33%) female participants in the cases and 36 (60.00%) male participants, 24 (40.00%) female participants in the controls. (Table 1). Mean height was 165.72 ± 8.18 (cm) in the cases and 165.10 ± 7.51 (cm) in the controls. Mean weight was 66.89 ± 11.43 (kg) in the cases and 66.87 ± 12.79 (kg) in the controls. Mean BMI was 24.85 ± 4.05 in the case and it was 24.07 ± 4.63 in the controls. Mean difference in weight, height and BMI between cases and controls was statistically insignificant (table-2). Among cases 88 (73.33%) participants had normal weight, 32 (26.67%) participants had over weight and among controls 47 (78.33%) participants had normal weight, 13 (21.67%) participants had over weight (Graph-1). Median heel pad compressibility index was 0.85(0.8 to 0.88) in cases group and it was 0.66(0.64 to 0.7) in control group. Median heel pad thickness in loading was 12.00(11.0 to 15.0) in cases group and it was 11.25(11.0 to 12.0) in control group. Median heel pad thickness in unloading was 15.00(13.0 to 16.0) in cases group and it was 18.00(17.0 to 18.0) in control group. The difference in the heel pad compressibility index, heel pad thickness in loading and heel pad thickness in unloading was statistically significant (P value <0.001) between cases and controls (Table-3) Among cases, age showed positive with heel pad compressibility index, heel pad thickness in loading with a r value of 0.26, 0.18 respectively (p<0.0%). BMI showed positive correlation with heel pad thickness in unloading with ar value of 0.22 (p<0.05). Heel pad parameters failed to show correlation with age and BMI except BMI which showed negative correlation (r=-0.32, p<0.05) with HPCI among controls (Table 4).

Median HPCI and HPTL were significantly higher in cases above 40 years compared to those in 25-40 years age group whereas among controls there was no significant difference in the media heel pad parameters. Median heel pad parameters were almost similar in normal and over-weight cases and controls except HPCI which was significantly higher in normal weight controls. All the median heel parameters were significantly higher in males compared to females among cases but among controls the parameters were similar for both males and females (Table-5).

Table 1: Comparison of Demographic variables between Cases and Controls

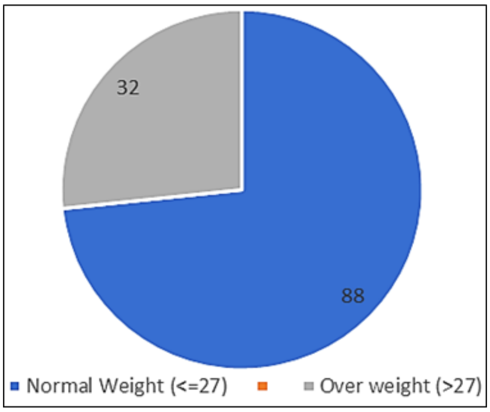
Parameter	**Cases (N=120)**	**Control (N=60)**	**P Value**
Age (in year)	43.97 ± 9.50	39.82 ± 11.22	0.0102†
Age Group			
25-42	50 (41.67%)	38 (63.33%)	0.0061*
43-60	70 (58.33%)	22 (36.67%)	
Gender			
Female	58 (48.33%)	24 (40.00%)	0.2899*
Male	62 (51.67%)	36 (60.00%)	

Note: *chi-square test, †-Independent sample t test

Table 2: Comparison of Anthropometric parameters between cases (N=120) and controls (N=60)

Parameter	Cases (N=120)	Control (N=60)	P Value
Height (in cm)	165.72 ± 8.18	165.10 ± 7.51	0.6203†
Weight (in kg)	66.89 ± 11.43	66.87 ± 12.79	0.9894†
Body Mass Index (BMI)	24.85 ± 4.05	24.07 ± 4.63	0.2462†

Note: *chi-square test, †-Independent sample t test



Graph 1: Distribution of study subjects according to BMI Grading

Table 3: Comparison of Heel pad related parameters between cases and controls (N=180)

Parameter	Cases (N=120)	Control (N=60)	P Value
	Median (Q1 to Q3)	Median (Q1 to Q3)	
HPCI	0.85(0.8 to 0.88)	0.66(0.64 to 0.7)	<0.001*
HPTL	12.00(11.0 to 15.0)	11.25(11.0 to 12.0)	0.0016*
HPT UL	15.00(13.0 to 16.0)	18.00(17.0 to 18.0)	<0.001*

*-significant

Table 4: Comparison of Heel pad parameters with Age, Body Mass Index (BMI) among cases (N=120) and controls (N=60) [spearman correlation]

Parameter	Cases		Controls	
	r value	P Value	r value	P Value
Heel pad compressibility index				
Age	0.26	0.0042*	-0.12	0.3808
BMI	0.07	0.4710	-0.32	0.0133*
Heel pad thickness in loading (HPTL)				
Age	0.18	0.0478*	-0.17	0.1931
BMI	0.18	0.0514	-0.17	0.2038
Heel pad thickness in unloading (HPT UL)				
Age	0.15	0.0925	0.11	0.3991
BMI	0.22	0.0165*	0.09	0.5136

*-Significant

Table 5: Comparison of Heel pad parameters with Age, BMI and gender among cases (N=120) and controls (N=60)

Parameters			Heel pad parameters, Median (Q1-Q3)		
			HPCI	HPTL	HPTUL
Cases	Age	25-40 (n=38)	0.84(0.8-0.87)	11.00(11.0-14.0)	14.00(13.0-16.0)
		>40 (n=22)	0.86(0.8-0.92)	13.00(11.0-15.0)	15.00(14.0-16.0)
	P value		0.0360*	0.0258*	0.0556
	BMI	Normal	0.85(0.8-0.89)	0.84(0.8 to 0.88)	15.00(13.0-16.0)
		Overweight	12.00(11.0-14.0)	14.00(11.0-15.0)	15.00(13.75-18.0)
	P value		0.2231	0.0615	0.1793
	Gender	Male	0.87(0.83-0.92)	14.00(11.0-15.0)	15.00(14.0-17.0)
		Female	0.84(0.78-0.87)	12.00(11.0-14.0)	14.00(13.0-16.0)
	P value		0.0110*	0.0113*	0.0281*
Controls	Age	25-40	0.66(0.64-0.68)	11.25(11.0-12.0)	18.00(17.0-18.0)
		>40	0.66(0.64-0.7)	11.25(11.0-12.0)	18.00(17.0-18.0)
	P value		0.3364	0.4248	0.4606
	BMI	Normal	0.66(0.64-0.7)	12.00(11.0-12.0)	18.00(17.0-18.0)
		Overweight	0.64(0.61-0.66)	11.00(11.0-12.0)	18.00(17.0-18.0)
			0.0304*	0.0998	0.3255
	Gender	Male	0.66(0.61-0.68)	11.00(11.0-12.0)	18.00(17.0-18.0)
		Female	0.66(0.65-0.7)	12.00(11.0-12.0)	18.00(17.0-18.0)
	P value		0.1624	0.2133	0.1382

Discussion

Among the study population, (66.67%) were Cases group having plantar heel pain and remaining (33.33%) were Control group without heel pain. The mean age was 43.97 ±9.50 (years) in the cases and 39.82 ± 11.22 (years) in the controls. Systematic review findings report that chronic plantar heel pain appears to occur most commonly between the age of 40 to 59 years 64 and in a mean age of 44 years which was consistent with this study.

There were (51.67%) male participants, (48.33%) female participants in the cases and (60.00%) male participants, (40.00%) female participants in the controls. Male predominance in this study was contrary to a study by Dufour, A, B., *et al*. which had 19% of men, 29% of women and study by Garrow *et al*. [2] in which, 20% of men and 24% of women reported foot pain. Menz *et al*. [12], Dunn, J, E., *et al*. [15] and another by Hill, C,L., *et al*. [16] also reported male predominance.

Overweight or obesity is suggested as a key factor associated with heel pain. The mean BMI was 24.85 ± 4.05 in the cases and it was 24.07 ± 4.63 in the controls. In the study no significant difference was noticed in BMI between cases and controls. This observation is contrary to a study by Lopez-Lopez, D., *et al.* [5] in which the mean BMI of participants with heel pain was 27.3+/-6.6 kg/m^2 while the mean BMI of participants without heel pain was found to be 25.6 +/-4.7kg/m^2. In a study by Hill, J, J., *et al.* [16] and another study by Snook, G, A., *et al*., [17] significant correlation was revealed between heel pain and increased body weight which was different from this study. The reason for this might be that most of the patients in the study were around 40 years of age and the cause of their heel pain might be related to their activity rather than their body mass index.

Median HPCI was significantly higher in cases group compared to controls (0.85 v/s 0.66). Median HPTL was significantly higher in cases group compared to controls (12.00 v/s 11.25). Median HPTUL was significantly higher in cases group compared to controls (15.00 v/s 18.00). These findings were similar to that found in study by Lopez- Lopez, D., *et al*. [5] who found that ultrasound-measured unloaded heel fat pad thickness was significantly lower in those with heel fat pad syndrome.

Prichasuk *et al*. [18], found that HPTL ranged from 14 mm to 27 mm and another study by Ozdemir *et al*. [7] also found a greater amount of sub calcaneal fat pad in patients afflicted with plantar pain. The authors state that the increased fat pad thickness produces a decrease in elasticity.

Among cases, median HPCI was 0.84 in age group 25 to 42 and it was 0.86 in age group 43 to 60. Among controls, median HPCI was 0.66 in age group 25 to 42 and it was 0.66 in age group 43 to 60. The difference in the HPCI with age was statistically significant among cases but not among controls.

Among cases, median HPTL was 11.00 in age group 25 to 42 and it was 13.00 in age group 43 to 60. Among controls, median HPTL was 11.25 in age group 25 to 42 and it was 11.25 in age group 43 to 60. The difference in the HPTL with age was statistically significant among cases but not among controls.

Among cases, median HPTUL was 14.00 in age group 25 to 42 and it was 15.00 in age group 43 to 60. Among controls, median HPTUL was 18.00 in age group 25 to 42 and it was 18.00 in age group 43 to 60. The difference in HPTUL with age was statistically insignificant among cases and controls.

The above observations were similar to that reported in a study by Hsu., *et al.* [19]. Which showed that the HPCI and HPTUL gradually increased with age. HPTUL, HPCI and energy dissipation ratio of the heel pad were significantly increased in the elderly group, indicating loss of the elasticity of the heel pad [19].

In the study the difference in the in HPTL and HPTUL with gender was not statistically significant. This finding is different from that found in study by Lopez-Lopez, D., *et al.* [5] in which the HPT of men and women was not the same. The reduced thickness in participants with heel pain was more pronounced in women than in men. In other similar studies like study by Uzel *et al.* [20] study by Prichasuk *et al.* [18] also obtained mean values of the fat pad thickness that were significantly higher in men than in women. In another study by Udoh *et al.* [21] the average fat pad thickness found using an ultrasound technique was 14.33 ± 0.24 mm in men and 12.14 ± 0.26 mm in women.

The study found positive correlation between age and HPCI and HPTL; between BMI and HPTUL in participants with heel pain. This finding was similar to that found in study by Prichasuk *et al.* [18] in which it was found that heel-pad thickness and compressibility increased with age. Increase in thickness and compressibility leads to loss of elasticity which might result in heel pain. Another study by Ozdemir, H, *et al.* [7] found that an increase in heel fat pad thickness with aging and increased body weight reduced the elasticity of the heel fat pad. In a study by Wearing S, C. *et al.* [22] negative correlation was found between age and heel pad thickness in unloading and between body mass index and heel pad parameters in participants without heel pain.

Conclusion

The study found difference in heel fat pad thickness and compressibility index between participants with and without heel pain. All the heel pad parameters showed positive correlation with age and BMI among the participants with heel pain. Hence it can be concluded that increase in heel pad thickness may result in heel pain due to decrease in elasticity.

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