Original Research

Effects of obesity on foot outcomes and quality of life in women with plantar fasciitis

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Abstract

Background & Aim: Plantar fasciitis (PF) is the most common foot dysfunction, which accounts for about 40% of all foot conditions. It limits activities of daily living (ADL) and quality of life (QoL). Obesity reduces the prognosis of many conditions. However, evidence is unclear on how it affects women with PF. This study aimed to identify the effects of obesity on foot outcomes in women with PF.

Methods: A cross-sectional study was conducted at the Departments of Rheumatology and Rehabilitation (General and Special) of the National Hospital of Sri Lanka. Fifty-four women with PF were recruited under three categories: obese (BMI>30), overweight (25<BMI<30), or not overweight (BMI<25), using simple random sampling. QoL and disability associated with PF were assessed using SF-36 and Foot Function Index (FFI). Ankle dorsiflexion range of motion, foot arch height, calf endurance, and ankle muscle strengths were measured using the Weight-bearing Lunge Test (WBLT), Static Arch Index, Calf Heel Raises, and Hand-held Dynamometer, respectively. Data were analyzed using one-way ANOVA and Tukey post hoc tests in SPSS v21

Results: Fifty-four women with unilateral plantar fasciitis with a mean age of 46.17 years (SD ± 5.08) and BMI of 27.19kgm-2 (SD ± 3.75) participated in the study. The higher BMI group had a significantly low SF-36 score (p=0.002) and higher FFI score (p=0.002), indicating poor QoL and higher suffering from plantar fasciitis despite the similar treatment they underwent. Furthermore, WBLT score (p<0.001) and dorsiflexor strength (p=0.033) were significantly lower in higher BMI categories, meaning less dorsiflexor range and strength in obese women. However, plantar flexor strength (p=0.827), calf endurance (p=0.887), and arch height (p=0.466) did not differ significantly across BMI categories.

Conclusions & Recommendations: Obese women with PF presented with lower QoL, poor foot functioning, and reduced dorsiflexor muscle strength and range of motion.

Keywords: *obesity, plantar fasciitis, quality of life, heel pain, body mass index, women*

Introduction

Plantar heel pain is the most prevalent foot complaint presented to foot and ankle specialists and musculoskeletal physiotherapists worldwide (1). As an umbrella term, "plantar heel pain" represents an assortment of various diagnoses, such as plantar fasciitis (PF) and other pathoanatomical causes of heel pain, heel fat pad syndrome, heel spur syndrome, nerve irritation, and calcaneal stress fracture (2–4). Regardless of gender, PF primarily affects people in their 40s to 60s. It is found to be the most common cause of heel pain in the United States, affecting 4% to 7% of the population (5). Approximately two million people seek treatment for PF annually, with an estimated annual treatment cost of 284 million dollars (5,6). The Dutch population demonstrated an annual incidence rate of 2-4 cases of plantar heel pain per 1,000 individuals (7). Research on foot problems in India revealed that 18% of participants reported heel pain (8). Generally, almost one in ten people develop PF during their lifetime (9). However, no specific data is currently available on the prevalence of plantar heel pain in Sri Lanka.

Plantar fasciitis is commonly considered to exist along a spectrum encompassing both inflammatory and degenerative characteristics, despite the name plantar fasciitis suggesting the disorder is mostly inflammatory (4). This can be an inflammation of the plantar fascia, which extends from the heel to the toes (2) which usually causes pain at the bottom of the heel. Medial plantar heel pain, together with discomfort at the medial calcaneal tubercle, are the hallmarks of plantar fasciitis (2,3,10). This pain increases in the morning and is aggravated by prolonged standing and walking (11). Anatomical risk factors such as limited ankle dorsiflexion, tight or weak calf muscles, increased heel pad thickness, and excessively pronated foot and special categories such as occupation, elderly, and obesity are known to contribute to developing PF (12–15).

Obese individuals tend to suffer from PF and foot pathologies more compared to normal-weight people (16). A study conducted to identify the association between body mass index (BMI) and plantar fasciitis among hospital staff in Dhaka City, Bangladesh, found that there is a strong correlation between plantar fasciitis in working status, duration, and BMI (17). The prevalence of foot discomfort was much higher in older persons than in young adults, affecting nearly all older adults over the age of 65 (18).

The prevalence of obesity among adults and children increases around the world. In the United States, 66.5% are overweight, and 32% are obese among men and women above 20 years (19). The prevalence of obesity in India varies from 11.8% to 31.3% and is identified as the main medical and financial burden to the government (20). Obesity often compromises an individual's active lifestyle because of pain and limitation in ankle range of motion (ROM) and may interfere with disease prognosis (15). Moreover, obese men and women tend to exhibit reduced physical and mental function (21). Obese older adults aged 60 to 90 years have been found to experience disabling foot pain, impaired foot function, and reduced foot-related quality of life (22). Compared to non-obese people, obese people may have greater foot pain, longer foot length, greater foot tissue thickness, and lower quality of life (23). A significant positive correlation between obesity and longer average plantar heel spur length has also been reported (24). Bariatric weight loss surgeries for obese individuals with plantar fasciitis have resulted in a reduction in post-surgical treatment appointments and the number of treatment modalities in treating plantar fasciitis, indicating that excess body weight might increase pain and risk factors related to plantar fasciitis (25).

Accordingly, obesity has been identified as a major risk factor causing foot problems among different populations. However, there is a significant gap in understanding its impact on the feet of active women aged 30 to 55 years (26). Women in this demographic often engage in physically demanding activities, balancing professional work with household responsibilities that involve prolonged standing and walking (27). They are at a heightened risk of acquiring foot issues due to the combined effects of obesity and high activity levels (28). Most of the available literature has focused on older or less active populations, overlooking the unique biomechanical challenges faced by active middle-aged women. Therefore, this study aimed to investigate the effect of obesity on the foot health of women aged between 30-55 years, which in return will support treatment plans for plantar fasciitis according to their BMI.

Methods

Participants

Fifty-four women with plantar fasciitis, attending physiotherapy treatments at the Departments of Rheumatology and Rehabilitation (General and Special) of the National Hospital of Sri Lanka, aged between 30-55 years, were recruited to the study via a simple random sampling method if fulfilled the inclusion and exclusion criteria. Women with a confirmed diagnosis of unilateral plantar fasciitis by a consultant in rheumatology and who were able to walk independently were included in the study, while neurological problems that affected walking, lower limb injuries, or surgeries in the previous six months were excluded. The sample size was calculated using a standard online sample size calculator (https://statulator.com/) (29) (The differences between two means=1.79, expected SD=1.91, power=80% and significance=0.05; two-sided; sample size: 54).

Ethical clearance was obtained from the ethics review committee of the Faculty of Medicine, University of Colombo (ERC No: UCP-AL-15-334).

Data collection method

Informed written consent was obtained from all the participants prior to the data collection. Each enrolled participant's height and body weight were measured using a portable stadiometer and electronic weighing scale. BMI was calculated by dividing body mass by height squared (kg/m^2). Participants were divided into obese (BMI>30), overweight (25<BMI<30), and not overweight (BMI<25) to obtain three groups (30). Next, the participants were given questionnaires and underwent the tests described below.

A. SF-36 questionnaire

The SF 36 questionnaire (ICC value=0.689-0.972) was used to assess participants' quality of life. Answers for 36 items in the questionnaire were numerically coded and combined to give scores for each health concept and a total SF-36 score out of 100, with a lower score indicating poorer health according to administration guidelines (31–33).

B. Foot Function Index (FFI)

The FFI questionnaire was given to obtain data on foot pain and activity restrictions. FFI measures the impact of the pain, disability, and activity restriction associated with foot pathology (34). This self-administered questionnaire has 23 items divided into three subheadings (pain, disability, and activity restrictions). The higher the final score, the more the patient is suffering from the foot-related condition (34). The FFI reported a high ICC value of 0.70-0.87 (35).

C. Arch Index (AI) method

The AI method was used to measure participants' foot arch height. This test has excellent test-retest reliability (ICC=0.99) (36,37) and is an indicator for arch height. Participants stood on the scale (Figure 1), and the footprint was taken when the scale indicated half of the body weight (38). A lower AI indicates a high-arched foot. An AI of less than 21%

classifies the foot as high-arched, while an AI greater than 28% indicates a flat foot (39).

D. Weight-bearing lunge test (WBLT)

The WBLT was used to measure the ankle dorsiflexion (inter-observer reliability of ICC=0.96; intra-observer reliability of ICC=0.98) (40). The participant was asked to maintain the maximum distance from the great toe to the wall while lunging forward with the testing knee and was able to touch the wall with the heel flat on the ground. The distance was recorded to the nearest 0.1cm as a tape measurement. The higher the distance, the dorsiflexion is higher (41,42).

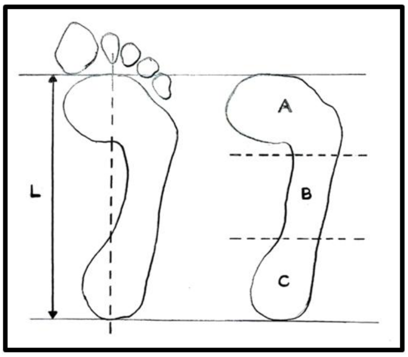
E. Calf heel raises test

This test (ICC=0.99) was used to assess the ankle plantar flexor endurance during a weight-bearing position. The participant was asked to stand on the edge of a step with heels off the step and then to raise the heel continuously (without a rest) at a rate of approximately one cycle per second until the participant was unable to raise through the full range with knees extended. The number of full cycles was counted and was taken as the total calf heel raises (40).

F. Ankle dorsiflexor-plantar flexor strength

This was measured as a maximum voluntary contraction (MVC) of ankle dorsiflexors and plantar flexors using a hand-held dynamometer (Lafayette™ Manual Muscle Tester-01165). The participant was positioned in long sitting with knees extended and feet over the edge of the table. The hand-held dynamometer was positioned between the metatarsal heads on the plantar surface of the foot and the wall to measure the plantar flexion. The participant was asked to plantar flex with maximal force, and the highest force was recorded. Then the participant was positioned in long sitting on the floor and the dynamometer was placed on the dorsal aspect of the foot proximal to the metatarsal heads to measure the dorsiflexion. The participant was asked to perform maximum dorsiflexion, and the highest force was recorded. The average was taken from three contractions with a minimum rest period of 10 seconds between each contraction (43,44).

All the measurements were taken on the same day, with adequate resting periods between each measurement.



AI = Area in the midfoot (B) / Total area of the footprint (A+B+C)

L: Length of the foot (excluding the toes); A: Forefoot; B: Midfoot; C: Heel

Figure 1. Static Arch Index calculation using footprint

Data analysis

Data were analysed using IBM SPSS version 21.0. Descriptive statistics were used to describe the demographic characteristics of the participants. The normality of variable distribution was tested and confirmed using the Shapiro-Wilk test. One-way ANOVA test was conducted to compare the demographic data and means of the parameters (SF-36 score, FFI score, WBLT score, calf heel raises score, dorsiflexion strength, plantar flexion strength, and foot arch index) among three BMI groups. Tukey post hoc test was performed to assess significant pairwise differences. Affected side distribution (left vs right and dominant vs non-dominant) between BMI groups was compared using the Chi-square test. The significance level was considered as $p<0.05$.

Results

Demographic characteristics of the study sample

The mean (SD) age and BMI of the study sample (n=54) were 46.17 (5.08) years and 27.19kgm^{-2} (SD=3.75), respectively (Table 1). Out of which 70.38% were housewives. Of the participants, 66.67% had right-side PF, and 62.96% reported PF in their dominant leg. The three BMI groups were not significantly different in their age (p=0.758) and affected side distribution (left vs right; p=0.779, dominant vs non-dominant; p=0.728). All women underwent the same physiotherapy treatments for their PF (Table 1).

The mean SF-36 score of the sample was 60.32 (SD=5.94). A significant difference was identified between the SF-36 and the three BMI groups (p=0.002). SF-36 score of non-overweight participants was significantly higher than overweight (p=0.018) and obese participants (p=0.003). However, the overweight and obese participants were not significantly different in their SF-36 scores (p=0.792) (Table 2). The mean (SD) FFI score was 58.06 (8.29) for the sample. There was a significant difference in the FFI among the three BMI groups (p=0.002). The obese group showed a significantly higher FFI than non-overweight (p=0.003) and overweight groups (p=0.014), while no significance was observed between non-overweight and overweight groups (p=0.839) (Table 2).

There were significant differences in WBLT scores among the three BMI groups in both the affected (p<0.001) and non-affected sides (p=0.004). Tukey post hoc comparisons revealed that non-overweight participants had significantly higher WBLT scores than overweight (p=0.000) and obese participants (p=0.000) on the affected side. However, for the non-affected side, the WBLT score of non-overweight participants was only significantly higher than obese participants (p=0.69). The overweight and obese participants were not significantly different in both affected (p=0.69) and non-affected side (p=0.139) WBLT scores.

Table 1. Demographic characteristics of the participants

Characteristic	Non-overweight (n=18)	Overweight (n=18)	Obese (n=18)	*p* value (Significance according to ANOVA)
Age, Mean (SD)	45.56 (5.26)	46.11 (5.27)	46.83 (4.90)	0.758
Height, Mean (SD)	157.89 (7.21)[a]	154.96 (7.41)	151.71 (4.84)[a]	0.025
Weight, Mean (SD)	56.64 (5.90)[b]	66.37 (5.73)[b]	71.92 (4.38)[b]	0.000
BMI, Mean (SD)	22.69 (1.55)[b]	27.64 (1.47)[b]	31.23 (0.59)[b]	0.000
Right side, No. (%)	12 (66.67%)	11 (61.11%)	13 (72.23%)	
Left side, No. (%)	6 (33.33%)	7 (38.89%)	5 (27.77%)	
Dominant side affected, No. (%)	12 (66.67%)	12 (66.67%)	10 (55.56%)	
Non-dominant side affected, No. (%)	6 (33.33%)	6 (33.33%)	8 (44.46%)	

[a] *Difference between non-overweight and obese groups according to Tukey post hoc test.*

[b] *Difference between non-overweight, overweight, and obese groups according to Tukey post hoc test.*

SD; Standard Deviation

Table 2. Comparison of SF-36 score and Foot Function Index (FFI) score between the body mass index BMI categories

Score	Non-overweight (n=18)	Overweight (n=18)	Obese (n=18)	*p* value (Significance according to ANOVA)
SF-36, Mean (SD)	64.09 (3.70)[a, b]	59.03 (6.61)[a]	57.86 (5.42)[b]	**0.002**
FFI, Mean (SD)	54.65 (7.09)[b]	56.10 (8.03)[c]	63.43 (7.24)[b, c]	**0.002**

[a] Difference between non-overweight and overweight groups according to Tukey post hoc test.

[b] Difference between non-overweight and obese groups according to Tukey post hoc test.

[c] Difference between overweight and obese groups according to Tukey post hoc test.

SF-36; 36-Item Short Form Survey, FFI; Foot Function Index

Table 3. Comparison of foot outcomes between the body mass index (BMI) categories

Test	Side	Group, Mean (SD)			*p* value Significance according to ANOVA
		Non-overweight (n=18)	Overweight (n=18)	Obese (n=18)	
Weight bearing lunge test (cm)	Affected	11.35 (0.98)[a, b]	9.51 (0.85)[a]	9.25 (1.06)[b]	**0.000**
	Non-affected	12.01 (0.91)[b]	11.45 (0.99)	10.77 (1.23)[b]	**0.004**
Calf heel raises	Affected	4.28 (0.86)	4.39 (0.67)	4.28 (0.75)	0.887
	Non-affected	5.11 (0.67)	4.94 (0.80)	4.72 (0.46)	0.219
Dorsiflexors strength (kg)	Affected	8.14 (0.67)[b]	7.80 (0.56)	7.61 (0.54)[b]	0.033
	Non-affected	9.21 (0.64)	8.90 (0.65)	8.74 (0.44)	0.069
Plantar flexors strength (kg)	Affected	9.11 (0.63)	9.23 (0.61)	9.23 (0.75)	0.827
	Non-affected	10.23 (0.45)	10.71 (0.60)	9.95 (0.83)	0.385
Arch Index	Affected	19.34 (2.95)	20.01 (1.79)	20.16 (1.25)	0.466
	Non-affected	22.59 (2.26)	23.49 (2.16)	24.04 (1.18)	0.083

[a] Difference between non-overweight and overweight groups according to Tukey post hoc test.

[b] Difference between non-overweight and obese groups according to Tukey post hoc test.

SD; Standard Deviation

Affected side dorsiflexor strength was significantly different among the three BMI groups (p=0.033) however, the non-affected side dorsiflexor strength (p=0.069) was not so. The post hoc test indicated that the affected side dorsiflexor strength of obese participants was significantly lower than non-overweight participants (p=0.010). Neither affected side nor non-affected side calf heel raises score, plantar flexors strength and arch index significantly differed among the BMI groups (Table 3).

Discussion

The results of this study indicate that the women with higher BMI (obese) demonstrate significantly reduced QoL, foot prognosis, dorsiflexor strength, and ankle ROM. However, increased obesity has not significantly affected calf muscle endurance, plantar flexor strength, or foot arch among women with PF.

Based on the results, it can be assumed that quality of life (QoL) decreases with increasing BMI values. This result is compatible with previously conducted studies (22,45,46). Higher age and higher levels of disability were found to be closely related to higher BMIs (45) and significantly lower SF-36 score levels, especially in the physical health domain, were reported in obese people (22). Moreover, those with a BMI value higher than 25kgm^{-2} have experienced more chronic plantar heel pain (46). Obese women experience higher vertical forces under the heel during walking and other activities of daily living (ADL) (47), increasing internal stresses at the heel (48). Furthermore, obese women tend to have higher plantar pressure, and the maximum pressure is located under the longitudinal arch. This may cause intense pain and decreased mobility, reducing the QoL during ADL.

Current findings reveal that obese women tend to have higher suffering from plantar fasciitis, which is compatible with the results of other studies (22,49,50). Obese women were reported with more foot pain (49), 17% more disability, and a higher incidence rate of foot pain and reduced functional performance (51) than normal weight counterparts. Furthermore, foot pain has been positively associated with fat mass. When women become heavier, their body weight generates more force upon the foot structures like ligaments, small joints, and intrinsic muscles of the foot, causing less prognosis and increased disability (50).

Our findings on muscle strength revealed dorsiflexor strength was reduced significantly in the obese group. This result aligns with a study conducted by Mickle and Steele (22), which found that obese adults experience significantly higher foot-related functional limitations and reduced dorsiflexor strength than their leaner counterparts. The significant reduction in ankle dorsiflexion range seen in our study has similarly been confirmed by other study findings (52,53). Obese children had reduced ankle dorsiflexion than normal-weight children (52,53), while Riddle et al. identified that limited ankle dorsiflexion can be a risk factor for future plantar fasciitis (53). However, Se-Yeon-Park and Du-Jin Park reported that individuals with BMI≤24 (non-overweight) and individuals with BMI≥25 (obese) were not different in their dorsiflexion ROM ($p=0.822$) and dorsiflexors strength ($p=0.641$). The participants' age distribution in their study was considerably different from our study because they recruited individuals in their 20s. The difference in the age distribution might be a reason for the contrasting results in dorsiflexors strength and ROM in the two studies (54). In plantar fasciitis, intrinsic muscles of the foot start deconditioning (55), and the elasticity of the plantar fascia and muscles becomes less, reducing the strength of dorsiflexors (53,56). Stretching and loading of the Achilles tendon increase pain and tension in the fascia, reducing dorsiflexion ROM (57).

Plantar flexor muscle strength, ROM, and endurance were not significantly affected in our study sample, which is similar to the study conducted by Phillips and McClinto, who studied gait changes in individuals with heel pain (58). The authors reported that the range and strength of plantar flexors do not change in heel pain. Moreover, Barnes et al. reported that chronic heel pain was not associated with plantar flexor endurance (59). According to a systematic review and meta-analysis done to identify the risk factors of physically active individuals, increased plantar flexion range of motion ((weighted mean difference (MD)=7.04°; 95% CI=5.88-8.19; $p<0.001$), body mass index (MD=2.13 kg/m^2; 95% CI=1.4-2.86; $p<0.001$), and body mass (MD=4.52 kg; 95% CI=0.55-8.49; $p=0.026$) were risk factors for PF. Interventions focused on addressing a greater degree of plantar flexion range of motion, body mass index, and body mass and their load on the force-absorbing plantar surface structures may be a good starting point in the prevention and treatment of active individuals with PF (60).

The current study could not find any significant difference in foot height among the three BMI categories. These findings were in contrast to Aurichio et al. and Jankowicz et al., who reported an increased arch index in the obese group. Both these studies found a positive correlation between the BMI and the arch index indicating flat feet among the obese group (31,61), although the mean age of elderly women in both studies was not similar: 69.4 years and 46.17 years, respectively. Jankowicz et al. suggest that long-term obesity contributes to significant changes in the arch index

(61). Intrinsic foot muscles, such as the abductor hallucis and flexor hallucis brevis, contribute to the medial longitudinal arch (55). The strength of these intrinsic muscles can be significantly reduced with obesity (22). Additionally, Hills et al. found that peak plantar pressure in obese women is under the longitudinal arch, which can be affected significantly with long-term obesity and consequently present with flatter feet (47).

The findings of this study need to be considered in the context of some limitations. Firstly, though the sample size was calculated, the number of participants representing each BMI category was low (n=18) in our study. Confounders such as individuals' physical activity level, gait characteristics, household work, and occupation, which affect foot outcomes and functions, were not considered in this study. Homogeneity in duration and onset of plantar heel pain among BMI groups was not assessed because nearly one-third of participants were not able to exactly remember the onset of their heel pain. Additionally, prior treatments received by patients for PF were not considered in the inclusion criteria. Provided that three BMI groups were heterogenous in heel pain onset, duration, and prior treatments, our results could change. However, we evaluated women aged between 30-55 years which is the most active age group in the household and at work (7) and the sample consisted of a wide spectrum of age (range of age;36-54 years) and BMI (range=17.38-32.42kgm^{-2}), strengthening the generalizability of results to a wider age and BMI population. All the participants were treated with the same physiotherapy protocol for PF and three BMI groups were homogeneous in their age and affected side (left vs right and dominant vs non-dominant). Hence, there were no effects on the results from ongoing treatments, age-related degenerative changes in foot and limb dominance. All the utilized questionnaires and tests were validated and highly reliable in measuring relevant parameters. The authors selected the clinical tests and instruments based on the clinical relevance and feasibility to use in a general clinical setting. For example, WBLT was selected over goniometry because it measures dorsiflexion ROM on a weight-bearing and functional posture.

Conclusions

Our study findings suggest that women with higher BMI (obese) showed significantly reduced QoL, foot prognosis, and dorsiflexor strength and range. However, obesity did not appear to have a significant impact on calf muscle endurance, plantar flexor strength, or foot arch. In-depth studies to investigate the impact of confounding factors are highly recommended.

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Author Declarations

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