Prevalence of Flexible and Rigid Flatfoot among Obese Individuals and its Association with Weakness of Tibialis Posterior Tendon

Sabiha Arshad[1], Hifza Noor[1], Hafza Khadim Hussain[1]
[1] Department of Rehabilitation and Allied Health Sciences, Riphah International University, Gulberg campus, Lahore, Pakistan

ABSTRACT:

Background: Flatfoot, also known as fallen arches, is a common foot condition characterized by a lack of arch support and abnormal pronation. It can be classified into two types: Flexible Flatfoot and Rigid Flatfoot. FFT is the most common form, accounting for approximately 70% of cases, while RFT is less common but more severe. Obesity is a major risk factor for flatfoot deformity, as excess weight puts additional stress on the foot. Weakness of the Tibialis Posterior Tendon, a key stabilizer of the arch, is also a significant contributor to flatfoot development.

Objectives: To determine the prevalence of Flexible Flatfoot (FFT) and Rigid Flatfoot (RFT) in obese individuals and explore their association with weakness of the Tibialis Posterior Tendon (TPT).

Materials and method: This study included 377 participants aged between 18 and 40 years old, with a diverse distribution across different age groups. Both genders were included with BMI of the obese category having flatfoot. In the current study, the focus was on evaluating the prevalence of flatfoot and types of flatfoot among the obese participants, distinguishing between unilateral and bilateral occurrences. Assessments, including the Navicular drop and single-limb heel-rise tests, were conducted to gather comprehensive data on foot structure and function. Statistical analyses also included Pearson chi-square tests to explore the associations between the prevalence and types of flatfoot with weakness of the tibialis posterior tendon.

Results: The number of participants included in this study was 377 with minimum age of 18 and maximum age of 40 years. Among the participants, there were 158 men and 219 women. Out of 377 individuals, 87 (23.1%) were unilateral and 290 (76.9%) were bilateral flatfoot. There were 26 (6.9%), 34 (9%), and 221 (58.6%) unilateral right, unilateral left and bilateral flexible flatfoot respectively. And 15 (4%), 10 (2.7%), and 71 (18.8%) unilateral right, unilateral left and bilateral rigid flatfoot respectively. There were 281 (74.5%) participants who had flexible flatfoot and 96 (25.5%) had rigid flatfoot. The Pearson chi-square test revealed a statistically significant strong association ($p<0.001$) between flatfoot occurrence and weakness of tibialis posterior tendon.

Conclusion: This study shows that there is a significant prevalence of both FFT and RFT in obese people and flexible flatfoot is more common than rigid flatfoot and the occurrence of flatfoot is strongly associated with Tibialis Posterior Tendon weakness.

Keywords: Flexible flatfoot, Obese, Rigid flatfoot, Tibialis posterior weakness

INTRODUCTION:

Obesity is a major public health problem, defined by WHO as excessive fat that poses a risk of health. Its worldwide prevalence has nearly doubled since 1980 and has been connected to chronic conditions and increased stress on lower extremities, including the feet. Research on obesity's impact on joint health has largely overlooked foot biomechanics, especially flatfoot deformities. Thus, it's vital to examine the prevalence and factors linked to flatfoot in obese individuals for a full understanding of obesity-related musculoskeletal problems (1).

The human foot has three segments: Hindfoot (Talus and Calcaneus), Midfoot (Navicular, Cuboid, and Cuneiforms), and Forefoot (Metatarsals and Phalanges), plus three arches: Medial Longitudinal, Lateral Longitudinal, and Transverse. These arches are vital for shock absorption, weight distribution, and movement. Flatfoot or pes planus is a condition whereby the sole touches the ground. This may be brought about by ligament laxity, neurological problems, muscular abnormalities, and other genetic causes. Among adults, the usual cause is posterior tibial tendon dysfunction. Flatfoot does include flexible flatfoot, which flattens underweight but recovers when weight is removed; rigid flatfoot, which stays flat with and without weight and can be associated with conditions including tarsal coalition or congenital vertical talus (2).

Excess stress on the foot resulting from obesity is highly responsible for flatfoot; this includes Flexible Flatfoot. Adults with this deformity often have it from a weakened posterior tibial tendon, which results in discomfort and stiffness. In Stage II PTTD, Flexible Flatfoot worsens as there is an increase in hindfoot eversion, while the hindfoot dorsiflexion decreases. The consequence of obesity on foot health, and the growing rates of obesity, means it is now necessary to establish how flatfoot types relate to posterior tibial tendon weakness, to develop effective prevention and treatment protocols (3).

Recent research has considerably contributed to the knowledge of relevant matters. Holla (2024) pointed out that prolonged occupational exposure along with non-ergonomic postures significantly increases the incidence of musculoskeletal disorders in pottery artisans in Bengaluru, underlining the influence of occupational factors on podiatric health (4). Payas (2024) researched adolescent flatfoot deformity and its association with developmental abnormalities in so-called cuneiform bones, revealing further research targeting developmental effects is required in flatfoot conditions (5).

K. Vijayakumar and Rameshkumar Subramanian assessed the validity of podoscopic images compared to traditional ink footprint methods for measuring foot arch angles. They evaluated the accuracy of the Arch Angle (AA), Chippaux-Smirak Index (CSI), Staheli Index (SI), and Arch Index (AI). Using SPSS software for statistical analysis, they employed the Intraclass Correlation Coefficient (ICC) to determine reliability (6).

The basis for this study becomes pertinent when one takes into account the concerning prevalence of flatfoot deformity in obese people and the crucial function the TPT plays in preserving the foot's stability and arch. Although several features of flatfoot and its associated pathophysiology have been examined in the past, there is a notable study gap that looks at the relationship between TPT deficit and the different types of flatfoot both Flexible and Rigid among obese people. Understanding this relationship is essential to develop the targeted treatments that improve therapeutic outcomes. Therefore, the future goal of the study was to improve the quality of life for obese people and offer recommendations for effectively managing their condition.

METHODOLOGY:

This is a cross-sectional study that aims to document the prevalence of flatfoot deformities among obese individuals. Rao soft computed the sample size with a margin of error amounting to 5% and a 95% level of confidence from an assumed population of 2,000, yielding 377 samples. The non-probability convenience technique for data collection involves gathering from Riphah International University, Lahore, and clinical settings. Such would be obese individuals, 18-40yr, presenting with a BMI of 30-34.9 (7), a positive navicular drop test with medial pain on heel raise, and intermittent chronic ankle pain. Traumatic injuries, neurological conditions, systemic diseases, pregnancy, recent injuries. Included were the following tests: Feiss Line Test for longitudinal arch evaluation (8), Toe Extension Test for differentiating between flexible and rigid flatfoot (9), Single Limb Heel Rise Test to assess posterior tibial tendon weakness, and lastly, the Navicular Drop Test, which serves to quantify foot pronation. Data was collected with the participants' consent and analyzed using SPSS 25.0 software. A Pearson Chi Square Test was conducted in computing the correlation, frequency, and percentage of all categorical data; means and standard deviation were used to depict the relationship and distribution of continuous variables.

RESULTS:

The number of participants in this research was 377 whose ages ranged from 18 to 40. Group 16 to 20 years had 29 (7.7%) participants, 86 (22.8%) belonged to group 21-25 years, 125 (33.2%) were from 26 to 30 years, 77 (20.4%) were from 31 to 35 years, and 60 (15.9%) were from 36 to 30 years (table 1). Apart from that, male and female participants were also reported by 158 (41.9 %) and 219 (58.1 %) respectively.

A comparison was made between the type of flatfoot and flatfoot development in the SHLR test which is shown in the SHLR test. SHLR testing had 60 flexible flatfoot unilateral and 221 bilateral, while on the SHLR testing, there were 69 bilateral and 27 unilateral stiffness cases. The results of the Pearson chi-square test were statistically significant ($p<0.001$). SHLT test having the foot was related to the kind of foot. On the SHLR test, there were 219 participants with both flat feet and 35 left and 27 right participants with flexible flat feet.

Also, 13 out of the respondents had rigid flat feet on the left side, 14 on the right side, and 69 were bilateral on the SHLR test showing the relationship between the SHLR test presence in the foot and the flat feet frequency, and the statistical difference that was significant $p<0.001$ was identified through the Pearson chi-square test. Forty individuals who had a flat right foot also had the presence of the right SHLR test. In this respect, 288 and 49 who had departed and had both flat feet had SHLT test positive on their foot. Statistical analysis with the Pearson chi-square test revealed that the corresponding difference was statistically significant at the level of $p<0.001$.

The incidence of flat feet was compared to those found in the SHLR test. Unilateral SHLR tests and flat tests were performed two times for them. Forty individuals had the absence of a flat right foot along with a right unilateral SHLR test. Similarly, two cases of left flat foot were checked, 47 people had a unilateral SHLR on the left foot, and 288 people who had bilateral SHLT tests for flat feet. When the relationship between the SHLR test results and flatfoot occurrence in the left, right, or both feet availed, the Pearson chi-square test issued a statistically significant difference $p<0.001$.

Table 1-A: Age of Patients

Age of patient (in Years)	Frequency (n)	Percentage (%)
16-20	29	7.7
21-25	86	22.8
26-30	125	33.2
31-35	77	20.4
36-40	60	15.9
Total	377	100.0

Table 1-A shows the frequency and percentage of different age group participants. There were 29 (7.7%) participants of group 16 to 20 years, 86 (22.8%) were belong to group 21-25 years, 125 (33.2%) were from 26 to 30 years, 77 (20.4%) were from 31 to 35 years, and 60 (15.9%) were from 36 to 30 years.

Table 1-B: Gender of patients

Gender of patient	Frequency (n)	Percentage (%)
Male	158	41.9
Female	219	58.1
Total	377	100.0

Table 1-B shows the frequency and percentage of male and female participants. 219 (58.1%) were females and 158 (41.9%) were male participants.

Table 2-A: Feiss line test

Feiss line test	Frequency (n)	Percentage (%)
Right foot	40	10.6
Left foot	48	12.7
Both	289	76.7
Total	377	100

Table 2-A shows the frequency and percentage of occurring of flat feet according to the feiss line test. There were 40 (10.6%) had right flat feet, 48 (12.7%) had left flat feet, and 289 (76.7%) had both flat feet.

Table 2-B: Types of flatfoot

<table>
<tr><th colspan="3">Type of flat foot</th><th>Frequency(N)</th><th>Percentage (%)</th></tr>
<tr><td rowspan="3">Flexible flatfoot</td><td rowspan="2">Unilateral</td><td>Right foot</td><td>26</td><td>6.9</td></tr>
<tr><td>Left foot</td><td>34</td><td>9.0</td></tr>
<tr><td>Bilateral</td><td>Bilateral</td><td>221</td><td>58.6</td></tr>
<tr><td rowspan="3">Rigid flatfoot</td><td rowspan="2">Unilateral</td><td>Right foot</td><td>15</td><td>4.0</td></tr>
<tr><td>Left foot</td><td>10</td><td>2.7</td></tr>
<tr><td>Bilateral</td><td>Bilateral</td><td>71</td><td>18.8</td></tr>
<tr><td colspan="3">Total</td><td>377</td><td>100</td></tr>
</table>

Table 2-B shows varying frequencies of flexible and rigid flatfoot types, with flexible bilateral flatfoot being the most common, comprising 58.6% of cases. Rigid unilateral flatfoot is the least frequent. There were 26 (6.9%), 34 (9%) and 221 (58.6%) unilateral right, unilateral left and bilateral flexible flatfoot respectively. And 15 (4%), 10 (2.7%) and 71 (18.8%) unilateral right, unilateral left and bilateral rigid flatfoot respectively.

Table 2-C: Flatfoot Occurrence in Obese Individuals

Flatfoot	Frequency (n)	Percentage (%)
Unilateral	87	23.1
Bilateral	290	76.9
Total	377	100

Table 2-C shows the frequency and percentage of flatfoot participants according to unilateral or bilateral. The 87 (23.1%) were unilateral and 290 (76.9%) were bilateral flatfoot participants.

Table 2-D: Type of flat foot

Type of flatfoot	Frequency (n)	Percentage (%)
Flexible flatfoot	281	74.5
Rigid flatfoot	96	25.5
Total	377	100

Table 2D shows the frequency and percentage of participants' type of flat foot. There were 281 (74.5%) participants who had flexible flatfoot and 96 (25.5%) had rigid flatfoot.

Table 3-A: Navicular Drop Test Values:

Navicular Drops Value	Frequency (n)		Percentage (%)	
	Right Foot	Left Foot	Right Foot	Left Foot
0-10	78	76	20.7	20.2
11-20	195	194	51.7	51.5
21-30	88	91	23.3	24.1
31-40	16	16	4.2	4.2
Total	377		100	

Table 3-A shows the frequency and percentage of participants' navicular drop test values of right and left feet. In the right foot, 78 (20.7%) participants had 0-10 value, 195 (51.7%) had 11-20 value, 88 (23.3%) had 21-30 value, and 16(4.2%) had 31-40 value. In the left foot, 76 (20.2%) participants had 0-10 value, 194 (51.5%) had 11-20 value, 91 (24.1%) had 21-30 value, and 16(4.2%) had 31-40 value.

Table 3-B: Single-limb heel-raise test (repetition in 60 seconds)

Single limb heel raise test (repetition in 60 sec)	Frequency (n)		Percentage (%)	
	Right Foot	Left Foot	Right Foot	Left Foot
0-10	119	90	31.6	23.9
11-20	225	250	59.7	66.3
21-30	33	37	8.8	9.8
Total	377		100	

Table 3-B shows the frequency and percentage of participants' single-limb heel-rise test of right and left feet in 60 seconds. On the right foot, 119 (31.6%) participants had 0-10 values, 225 (59.7%) had 11-20 values, and 33 (8.8%) had 21-30 values. On the left foot, 90 (23.9%) participants had 0-10 values, 250 (66.3%) had 11-20 values, and 37 (9.8%) had 21-30 values.

Table 3-C: SHLR test presence in Feet

SHLR test presence in Feet	Frequency (n)	Percentage (%)
Right foot	40	10.6
Left foot	49	13.0
Both	288	76.4
Total	377	100

Table 3-C shows the frequency and percentage of participants' flat foot laterality according to the SHLR test. 40 (10.6%) had right flat feet and 49 (13%) had left flat feet, and 288 (76.4%) had both flat feet.

Table 4: Association of SHLR Test with Type and Flatfoot

Pearson Chi-Square	Value	Df	P-Value
Association of Weakness of Tibialis posterior Tendon with flat foot	377.000	1	.000
Association of Weakness of Tibialis posterior Tendon with types of flatfoot.	1.849	1	.174

Table 4 shows the Chi-Square values. The results indicate a highly significant association between weakness of Tibialis posterior Tendon and flatfoot (either unilateral or bilateral) with a p-value < 0.001. This means there is a strong statistical relationship between weakness of Tibialis posterior Tendon and the presence of flatfoot. Whereas the Chi-Square tests indicate that there is no statistically significant association between weakness of Tibialis posterior Tendon and the types of flatfoot (either flexible or rigid) as the p-value is greater than 0.05, suggesting that the relationship between weakness of Tibialis posterior Tendon and types of flatfoot is not significant based on this dataset.

DISCUSSION:

The purpose of this study was to ascertain the frequency of both rigid and flexible flat feet in obese people, with a focus on tibialis posterior tendon weakening. By raising the risk of flat feet and weakening tendons, obesity can have an impact on the health of the feet. The formation of flat feet may be attributed to the malfunction of the tibialis posterior tendon, which is essential for maintaining the arch of the foot while carrying too much weight. There were 219 women (58.1%) and 158 males (41.9%) among the 377 participants, who were all between the ages of 18 and 40 years. There were 26 (6.9%), 34 (9%), and 221 (58.6%) unilateral right, unilateral left and bilateral flexible flatfoot respectively. And 15 (4%), 10 (2.7%), and 71 (18.8%) unilateral right, unilateral left and bilateral rigid flatfoot respectively. There were 281 (74.5%) participants who had flexible flatfoot and 96 (25.5%) had rigid flatfoot. The Pearson chi-square test revealed a statistically significant strong association ($p<0.001$) between flatfoot occurrence and weakness of tibialis posterior tendon.

There is lack of literature on this issue but still some studies available in supporting research and also emphasizes how obesity affects people with foot abnormalities. Regardless of the surgical technique employed, a 2021 study by Amr A. Fadel et al. on double and triple arthrodesis for adult-acquired flatfoot deformity (AAFD) stage III demonstrated significant improvements in radiographic measures and functional outcomes (10). Strongly supports the current study that there is association.

Heng et al. looked into the connection between flatfoot people's first ray mobility and posterior tibial tendon dysfunction (PTTD). It is possible that first ray mobility is not the main factor contributing to the development of PTTD, as their results did not reveal any significant variations in first ray displacement between PTTD patients and asymptomatic controls. Tarawifa conducted a cross-sectional study that found a significant association between obesity and flat foot incidence, highlighting a strong link between BMI and flat feet (11).

Fauerfa et al. (2023) looked into the relationship between the incidence of flat feet and obesity among 102 academic members of Universitas Jambi's Faculty of Medicine and Health Sciences. According to the study, flat feet occur in 20.6% of people, with obesity accounting for 45.7% of cases. There was found to be a strong correlation between the incidence of flat feet and obesity. The study found that among these academic members, there is a significant correlation between BMI and flat feet (12).

CONCLUSION:

This study investigated the relationship between Flatfoot and Tibialis Posterior Tendon weakness in obese individuals. The results showed that obese individuals are more likely to have Flatfoot, with Flexible Flatfoot (FFT) being more prevalent than rigid flatfoot (RFT). There is a strong association of weakness of the Tibialis Posterior Tendon with Flatfoot but a weak association with types of flatfoot. The study highlights the importance of addressing obesity and strengthening the Tibialis Posterior Tendon to prevent or manage Flatfoot deformity.

REFERENCES:

1. Purnell JQ. What is obesity?: Definition as a disease, with implications for care. Gastroenterology Clinics. 2023;52(2):261-75.

2. Sarkar A, Sawhney A. Effects of body mass index on biomechanics of adult female foot. MOJ Anat & Physiol. 2017;4(1):232-6.
3. Kaur M, Kaur N. Prevalence of flexible and rigid flatfoot among adolescents and its association with body mass index. Physiotherapy-The Journal of Indian Association of Physiotherapists. 2024;18(1):28-33.
4. Holla P, Shenai AV. Work-related musculoskeletal disorders among traditional pottery makers at selected places in Bengaluru–A cross-sectional study. Physiotherapy-The Journal of Indian Association of Physiotherapists. 2024;18(1):20-7.
5. Payas A, Batin S. Is a keystone Bone Anomaly the Main Cause of Flatfoot (Pes Planus)? Journal of Pediatric Orthopaedics. 2024:10.1097.
6. Vijayakumar K, Subramanian R, Senthilkumar S, Dineshkumar D. An Analysis of Arches of Foot: A Comparison between Ink Foot Print Method and Custom Made Podoscope Device Method. Journal of Pharmaceutical Research International. 2021;33(34B):249-56.
7. Bray GA. Beyond bmi. Nutrients. 2023;15(10):2254.
8. Barutcu E, Paksoy B, Selcuk M, Karaca O, Yilmaz K. Effects of Pes Planus on Foot Pain, Low Back Pain, and Static Balance in Young Adult Individuals. Acibadem Saglik Bilimleri Dergisi. 2024;15(3).
9. Dejonghe R. CHARACTERISTICS OF INTRINSIC FOOT MUSCULATURE IN INDIVIDUALS WITH ASYMPTOMATIC FLEXIBLE FLATFOOT AND THE EFFECT OF EXERCISE THERAPY: Ghent University; 2023.
10. Fadle AA, El-Adly W, Attia AK, Mohamed MmM, Mohamadean A, Osman AE. Double versus triple arthrodesis for adult-acquired flatfoot deformity due to stage III posterior tibial tendon insufficiency: a prospective comparative study of two cohorts. International Orthopaedics. 2021;45:2219-29.
11. Heng ML, Krishnasamy P, Kong PW. First ray mobility and posterior tibial tendon dysfunction (PTTD) in persons with flatfoot: A case-control study. The Foot. 2018;37:57-60.
12. Tarawifa S, Enis RN, Shafira NNA, Puspasari A, Putra SE. The The Association Of Obesity With The Incident Of Flat Foot In Adults: A Cross-Sectional Study Of Academic Community In Jambi City. Jambi Medical Journal: Jurnal Kedokteran dan Kesehatan. 2023;11(4):442-9.

Authors Detail

First Author: Sabiha Arshad
Senior Lecturer / Physiotherapist at Department of Rehabilitation and Allied Health Sciences, Riphah International University, Gulberg campus, Lahore, Pakistan
Second Author: Hifza Noor
Student at Riphah International University, Gulberg campus, Lahore, Pakistan
Third Author: Hafza Khadim Hussain
Student at Riphah International University, Gulberg campus, Lahore, Pakistan