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Prevalence of Flat Feet Among Female and its Association with the Use of Flat-Soled Footwear -A Cross Sectional Study

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ABSTRACT

Background: Flat feet (pes planus) is a common condition in which the arch of the foot becomes flattened. Many females preferred wearing flat-soled shoes such as slippers, sandals, or pumps, which did not provide proper arch support. Wearing such shoes for long hours put pressure on the feet and could cause changes in the arch over time. Due to fashion, daily routines, and prolonged standing hours, young females were at higher risk. Studying this condition helped to create awareness and guide people to choose better footwear for maintaining healthy feet.

Objective: To identify the prevalence of flat feet (pes planus) among females who habitually wore flat-soled footwear and to evaluate medial longitudinal arch function using the Navicular Drop Test, while also exploring how the frequency, duration, and type of flat footwear used were related to the development of flatfoot.

Methodology: This was a cross-sectional study that included female students aged 18–25 years who wore flat-soled shoes at least four days per week. A total of 109 participants were selected through convenience sampling from Indus University and Jinnah Sindh Medical University. Basic information such as age, BMI, and footwear habits was recorded. The Navicular Drop Test was used to assess foot posture and identify flat feet. Data were analyzed using SPSS version 26, and results were presented in graphs and tables as frequencies and percentages.

Result: A total of 109 female participants were included in the study. Most participants were above 20 years of age (89%) and had a BMI greater than 20 kg/m² (64.2%). The majority were right-foot dominant (77.1%) and reported moderate physical activity levels. Flat-soled footwear was commonly used among participants, with many reporting regular use for more than five years. The Navicular Drop Test (NDT) demonstrated marked navicular drop (≥10 mm) in 40.4% of right feet and 37.6% of left feet, indicating excessive pronation. Foot posture assessment showed that 70% of right feet and 65% of left feet had pronated or flatfoot posture. Higher BMI, increasing age, and prolonged use of flat-soled footwear were associated with greater navicular drop and altered foot posture. A statistically significant association was observed between the use of flat-soled footwear and the prevalence of flat feet among participants (p <

0.05), while most participants did not report foot pain, recurrent ankle discomfort, or use of orthotic supports.

Conclusion: The present study highlights the importance of the medial longitudinal arch in maintaining foot stability, balance, and normal gait. Alterations in foot arch structure, influenced by factors such as body weight, lifestyle, and prolonged use of flat-soled footwear, may lead to flatfoot and changes in foot posture. In this study, a high prevalence of flatfoot and pronated posture was observed among female participants, with marked navicular drop more common in the right foot. Most participants were above 20 years of age, had higher BMI, and demonstrated right-foot dominance. Although foot pain, ankle discomfort, and orthotic use were low, dominant foot showed a significant association with NDT outcomes. The findings emphasize the need for awareness regarding appropriate footwear, early screening, and preventive strategies to improve foot health and reduce future musculoskeletal complications among females.

Keywords(Mesh Terms): Flat feet, Pes planus, Flat-soled footwear, Foot posture, Navicular Drop Test, Foot biomechanic.

INTRODUCTION

The foot's natural stability comes from three main arches: the medial longitudinal arch, the lateral longitudinal arch, and the transverse arch. The medial longitudinal arch is made by the bones on the inner side of the foot and is supported by strong plantar ligaments, especially the spring ligament. The lateral longitudinal arch is on the outerside of the foot, and the transverse arch runs across the foot at the tarsometatarsal area, helping to support body weight and keep balance [1]. The anatomy of the foot is typically divided into three main segments: the hindfoot, midfoot, and forefoot. The hindfoot consists of the talus and calcaneus, forming the heel. It plays an essential role in gait, as it is the first part of the foot to contact the ground and influences the movement of the other segments. The midfoot is made up of the navicular, cuboid, and three cuneiform bones. Although these bones have limited movement relative to each other, the midfoot provides both mobility and stability, helping transfer motion from the hindfoot to the forefoot. The forefoot includes the five metatarsals and all the phalanges, allowing the foot to adapt to different ground surfaces through subtle shape changes. The foot contains a major structural feature known as the medial longitudinal arch (MLA), formed by the calcaneus, talus, navicular, three cuneiforms, and the first three metatarsals. This arch connects the hindfoot and forefoot and plays a key role in weight distribution and shock absorption. Because of its height, the MLA does not normally touch the ground during standing. It is supported by the spring ligament, which helps the arch regain its shape during loading and unloading [2].

The complex anatomy of the foot is essential for mobility, support, and balance of the lower limb. The foot's structure, including bones, ligaments, and muscles, forms the medial longitudinal arch, which absorbs shock and distributes weight during walking or running. Changes in the height or shape of this arch, influenced by factors such as genetics, body weight, or footwear, can lead to conditions like pes planus, or flatfoot. In flatfoot, the arch is reduced or absent, which can alter walking patterns and increase the risk of muscle and joint problems[3].Because arches define the plantar surface contact area of the foot and ultimately help detect flat feet, consistent measurements can be used to determine foot types based on their arches [4]. Flat feet, or pes planus, occur when the arch of the foot collapses, making the entire bottom of the foot rest on the ground. While this condition doesn't always cause symptoms, it can sometimes lead to pain or movement problems, especially with overuse or poor footwear. Flat feet can also change the way your legs and lower back move, which may contribute to discomfort or a higher chance of injury [5].
The foot is very important for moving around. It helps absorb shock, balance the body, and push off the ground when walking or running. If the foot's shape is not normal, it can make walking or running harder.

Flat feet often get better over time, but in teenagers, the condition can be caused by both body changes and outside factors like shoes, activity, or habits [6]. Any change from the normal flat position of the foot is called a foot deformity. The two main types are high arch (pes cavus) and flat foot (pes planus). In pes cavus, the inner arch of the foot is higher than normal, creating a curved shape. In pes planus, the arch is flattened, causing the entire sole of the foot to rest on the ground [7].

The prevalence of flatfoot varies across regions and populations due to factors such as genetics, lifestyle, and footwear habits. A study in Lahore, Pakistan, reported that 40.6% of people had flat feet, indicating that the condition is relatively common. Rates in other countries differ, reflecting variations in environmental and hereditary factors [8]. In contrast, research in India reported that about 14.4% of young adults aged 18–21 years had flexible flatfoot, showing that the prevalence can vary significantly between populations [9]. In China, the prevalence of flat feet is about 5.5%, with similar rates for males and females [10].Flat feet are more common in women, possibly because of differences in foot structure (shorter legs and higher arches), wearing high-heeled shoes, and hormonal changes during pregnancy that loosen the ankle ligaments and arches [11].

A normal flat foot is usually flexible and can get better when the legs aren't under too much weight. A problem flat foot is stiff and can come from birth or develop due to injuries, muscle or nerve problems. Flat feet can make walking hard, cause tiredness, affect balance, and increase the chance of falling, which can make daily activities harder for children [12].The posterior tibial tendon (PTT) is a key tendon that plays a major role in supporting the inner arch of the foot and controlling its movement. It runs from the back of the leg, passes behind the inner ankle, and attaches to several bones in the middle and back of the foot. Its main function is to help the foot turn inward and maintain stability during walking, running, and other movements. Part of the tendon has less blood supply, which makes it more vulnerable to injury or tearing. When the PTT becomes weak or damaged, the foot can start to tilt outward, the arch may collapse, and the ligaments and muscles supporting the foot can stretch or change position, leading to a deformity. Over time, this can cause ankle instability, alter the overall shape of the foot, and may result in arthritis in the midfoot and hindfoot, making walking painful and limiting mobility. Proper function of the PTT is therefore essential for maintaining balance, efficient movement, and overall foot health [13].

Many studies have explored the walking patterns of adults with flatfoot, showing clear differences in leg movements based on age and gender. Research has found that age, gender, and obesity affect the stiffness and structure of the foot arch. A high BMI especially influences foot posture and stability, particularly in younger people. To the best of my knowledge, the combined effect of BMI, age, and gender on the movement and forces of flatfoot has not been reported yet. Therefore, studying foot biomechanics including motion and forces during different walking phases in normal and flatfoot, while considering age, gender, and BMI, becomes very important [14].Flat feet can cause several problems, including pain, instability, uneven pressure on the soles of the feet, difficulties with walking, and general foot fatigue. These issues can make daily activities more challenging and tiring. Over time, they may also affect a person's walking pattern, leading to slowerwalking speed, shorter steps, fewer steps per minute, and longer time spent with the foot on the ground during each step.

All of these changes can reduce overall mobility, physical function, and quality of life, making routine tasks more difficult and affecting general well-being [15].The main problem with pes planus is that the foot pronates too much when standing or walking. This causes uneven distribution of weight during walking, puts extra stress on the foot and ankle joints, creates pressure and shearing forces in the knee, and leads to inward rotation of the hip. People with pes planus need to use their plantar intrinsic muscles and tibialis posterior more to support the medial longitudinal arch and keep the foot stable while bearing weight. Over time, this extra effort can cause muscle fatigue and weakness [16].

Causes of flatfoot include a range of factors such as problems with the posterior tibial tendon, injuries, inflammatory arthritis, Charcot arthropathy, and congenital conditions like tarsal coalition. Among adults, the most common cause is dysfunction of the posterior tibial tendon. This condition is frequently associated with factors like obesity, diabetes, high blood pressure, previous trauma, or corticosteroid injections, all of which can contribute to weakening or damage of the tendon and lead to the collapse of the foot's arch [17].Adults can develop foot instability because of repeated injuries or weakening of ligaments and tendons over time. Body weight is an important factor that affects the shape and working of the foot. Foot problems are more common in overweight and obese people because the feet have to carry extra body weight, which puts more stress on the foot structures. Since the feet are always in contact with the ground, they face repeated pressure and load. Acquired pes planus can develop due to lower limb injuries, long-term abnormal stress on the foot, obesity, illness, or poor body alignment. High body mass index is often related to a sedentary lifestyle and high-fat, high-calorie diet. As people grow older, metabolism and muscle strength decrease, which leads to weight gain. The combination of increased body weight and weak muscles puts extra stress on the foot arches, causing the arches to collapse and changing how the foot touches the ground [18].

Radiographs are a reliable way to assess the medial longitudinal arch, but they are expensive and involve radiation, making them less suitable for large studies. Indirect methods, like using non-toxic colored footprints, are simple, fast, reliable, non-invasive, and inexpensive, and have been shown to match well with X-ray results. Footprint analysis is often used to identify, classify, and monitor flat feet. Other methods include ultrasound, which provides dynamic images of soft tissues, CT scans, which give detailed 3D images of bones, and MRI, which provides detailed information about soft tissue abnormalities in the foot and ankle [19]. Clinical diagnosis of flat foot was done by observing the heel position, the navicular bone, and the medial arch while standing, using Tachdjian's grading system (1990). If the medial arch was visible, the foot was considered normal. A slightly flattened arch was graded as mild flat foot. If the arch was not visible or the navicular bone had shifted medially and could be felt, it was considered moderate flat foot. Severe flat foot was when the inner border of the foot appeared convex [20]. In adults, flat feet may not always cause problems, and a normal quality of life is possible. However, they can sometimes become painful and disabling. If left untreated, symptomatic flatfoot can affect independence, daily activities, and overall well-being. The first treatment for flexible, painful flatfoot is usually non-surgical, including orthotic devices, physical therapy, and anti-inflammatory medications. If these treatments are not effective, surgery may be considered to correct the deformity [21].

Flatfoot may be congenital or acquired. Congenital flatfoot is a birth-related condition where the foot arches do not form properly from the start. Congenital flatfoot is divided into two types; flexible and rigid [22]. Flexible flat feet are more common and the arch may appear when the foot is not bearing weight. On the other hand, rigid flat feet are much less common, affecting less than 1% of the population. In rigid flat feet, the arch is permanently low and does not change whether the person is standing or sitting, making this type more likely to cause discomfort and functional problems [23]. Acquired flatfoot is a condition that appears over time, often caused by factors like injuries, weakened muscles, aging, or consistently wearing improper footwear. Acquired adult flatfoot deformity is divided into four stages. Stage I involves pain and inflammation of the posterior tibial tendon, but the tendon still functions normally. Stage II is split into IIa and IIb: IIa includes flatfoot with tendon pain and dysfunction, while IIb patients have normal hindfoot movement and forefoot abduction but cannot perform a single-leg heel raise. Stage III also involves tendon dysfunction, but the hindfoot joints become stiff and may develop arthritis. Stage IV is an advanced stage of stage III, with added ankle joint misalignment due to long-standing hindfoot valgus [24].In the early stages of flatfoot (I and II), non-surgical treatments are usually tried first and often relieve symptoms. Surgery is usually needed in more advanced cases. Stage II can be treated with bone realignment (osteotomies) and soft tissue procedures, stage III often requires triple joint fusion (arthrodesis), and stage

IV, which involves the ankle, may need ankle replacement or fusion, sometimes along with deltoid ligament repair and foot realignment. For stiff flatfoot, conservative treatments include anti-inflammatory medications, corrective footwear, or casting [25]

Significance: Flat feet (pes planus) is a common condition that changes how the foot works, causing pain, tiredness, and a higher risk of injuries in the legs and back. Women may be more at risk due to anatomy and hormonal factors, and wearing flat-soled shoes can make it worse. Even though it affects daily life and musculoskeletal health, there is little research on the link between flat shoes and flat feet in women. Studying this can help with prevention, better footwear choices, and reducing related health problems.

Research Question: To determine the prevalence of flat feet among females who use flat- soled footwear?

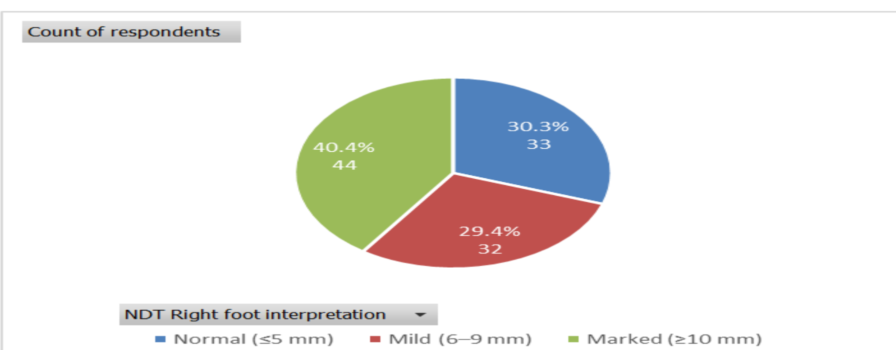
METHODOLOGY:

- **Study Design:** This study was a cross-sectional study.
- **Sample Technique:** A non-probability convenience sampling technique was used in this study.
- **Data Analysis**: The data were analyzed using descriptive statistics and were presented in the form of frequencies and percentages using pie charts and bar graphs. Data were entered and analyzed using SPSS version 26.

RESULTS AND FINDINGS

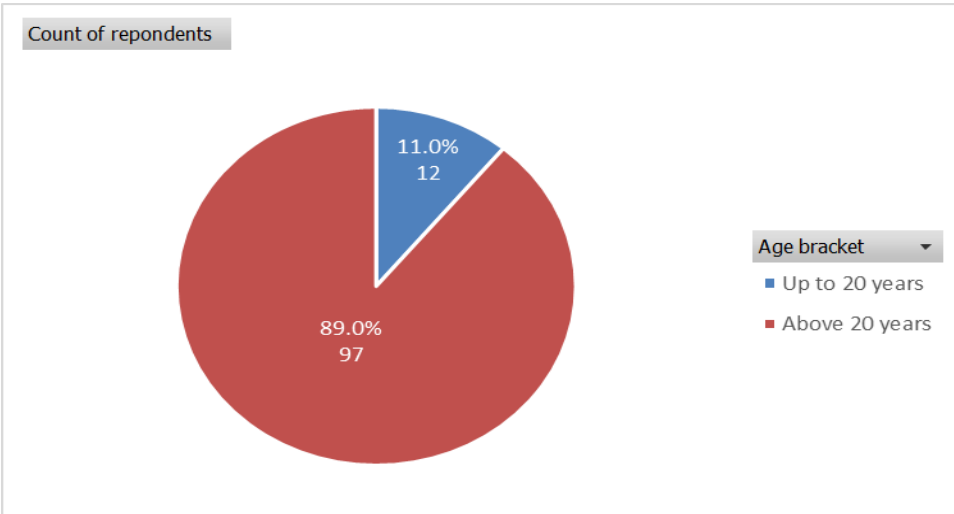
A total of 109 female participants aged 18–25 years were included in this study. Most participants were above 20 years of age (89.0%) and had a BMI above 20 kg/m² (64.2%). The majority were right-foot dominant (77.1%) and reported moderate physical activity levels (79.8%). Most participants commonly used slippers or chappals (54.1%), while 40.4% reported sometimes wearing flat-soled footwear and 35.8% reported mostly wearing it.

Chart 1: NDT Results of Right Foot



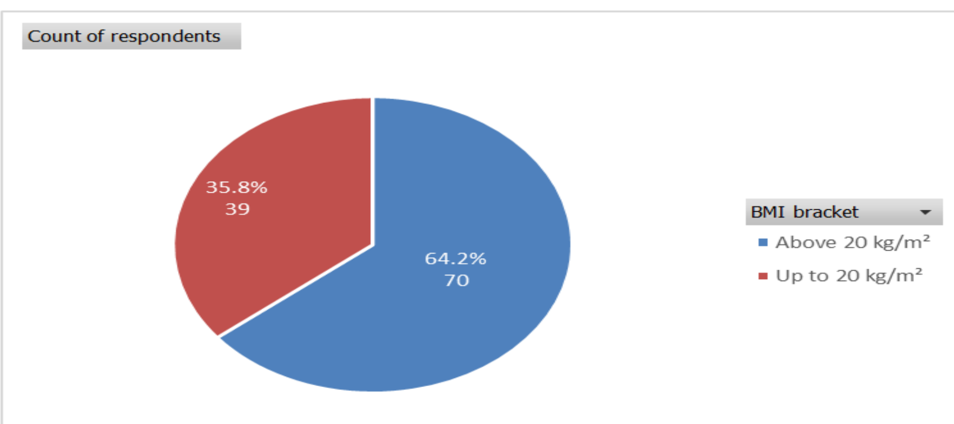
The distribution of Navicular Drop Test (NDT) results for the right foot among the respondents shows that the largest proportion, 44 participants (40.4%), exhibited a marked navicular drop (≥10 mm), indicating a tendency toward a pronated or lower-arched foot posture. Meanwhile, 33 participants (30.3%) had normal navicular drop values (≤5 mm), and 32 participants (29.4%) demonstrated mild navicular drop (6–9 mm). These findings suggest that while a substantial number of participants maintain normal or mild foot posture, a significant portion displays marked deviations, highlighting the prevalence of altered foot structure in the study population.

Figure 1: Age-wise NDT right foot findings



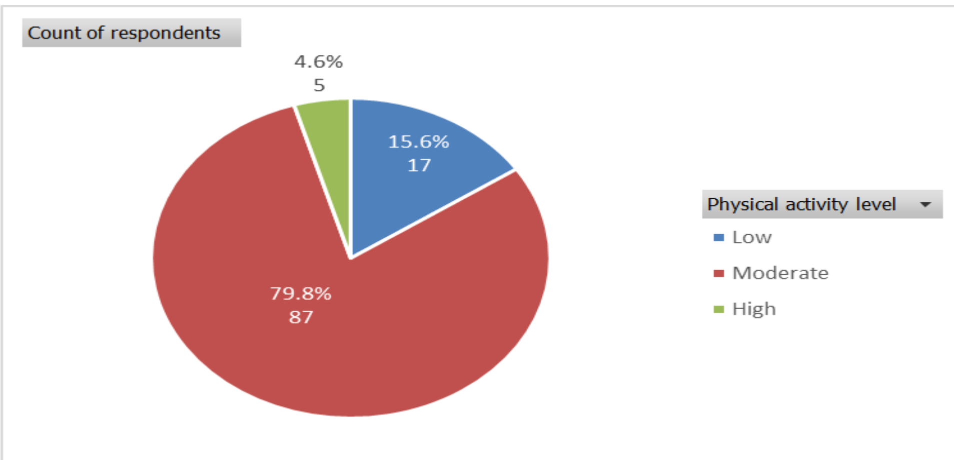
The Navicular Drop Test (NDT) results for the right foot indicate a clear trend across age groups. Among participants up to 20 years, 4 individuals showed a normal navicular drop (≤5 mm), 5 had a mild drop (6–9 mm), and 3 exhibited a marked drop (≥10 mm). In contrast, participants above 20 years demonstrated higher values, with 29 in the normal range, 27 showing mild drop, and 41 presenting marked drop. Overall, the data suggest that a marked navicular drop is more prevalent in the older age group, indicating a tendency toward increased foot pronation or reduced medial longitudinal arch height with age. Younger participants mostly fall within the normal or mild categories, reflecting generally healthier or more stable foot posture in this group.

Figure 2: BMI-wise NDT right foot findings



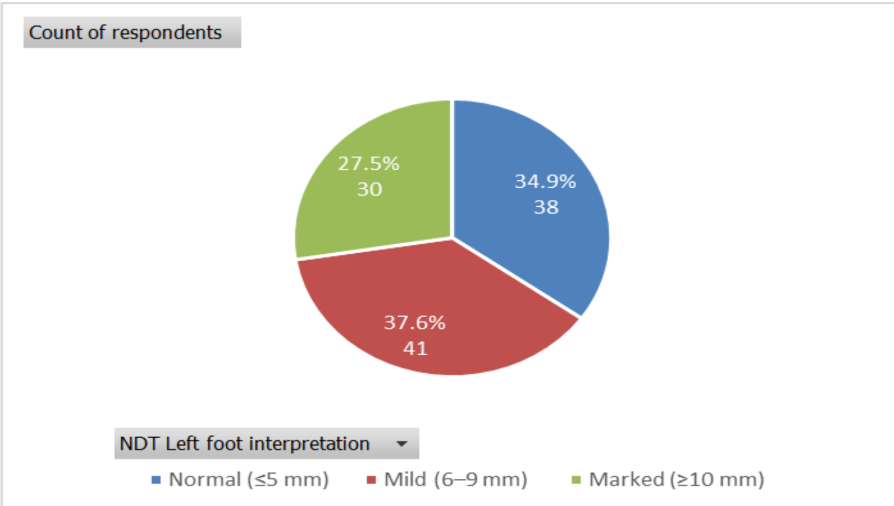
The Navicular Drop Test (NDT) results for the right foot, analyzed by BMI categories, reveal notable differences. Among participants with a BMI up to 20 kg/m², 15 individuals had a normal navicular drop (≤5 mm), 11 exhibited a mild drop (6–9 mm), and 13 showed a marked drop (≥10 mm). In participants with a BMI above 20 kg/m², 18 were in the normal range, 21 had mild drop, and 31 presented marked drop. These findings suggest that participants with higher BMI are more likely to demonstrate mild to marked navicular drop, indicating a greater tendency toward foot pronation or decreased medial longitudinal arch height. Conversely, participants with lower BMI are comparatively more likely to have a normal navicular drop, reflecting better arch stability.

Figure 3: Physical activity-wise NDT right foot findings



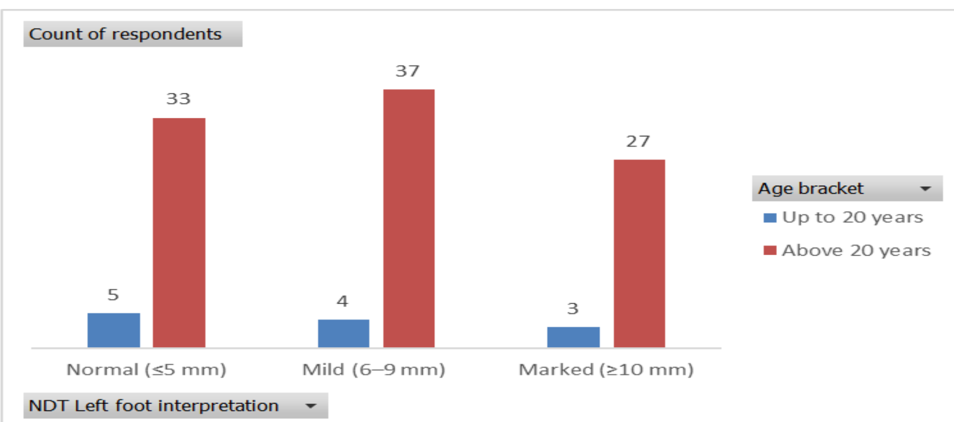
The Navicular Drop Test (NDT) results for the right foot, categorized by physical activity levels, show distinct patterns. Among participants with low physical activity, 5 had a normal navicular drop (≤5 mm), 4 exhibited mild drop (6–9 mm), and 8 showed marked drop (≥10 mm). In the moderate activity group, the majority fell within the normal (26) or mild (28) categories, with 33 participants showing marked drop. For the high activity group, only a few participants had normal (2) or marked (3) navicular drop, while no data were reported for mild drop. Overall, participants with moderate activity appear more frequently in all NDT categories, while high activity participants are fewer but show a tendency toward both normal and marked drops. Low activity participants have a relatively higher proportion with marked drop, suggesting that limited physical activity may be associated with decreased medial longitudinal arch stability.

Chart 2: NDT Results of Left Foot



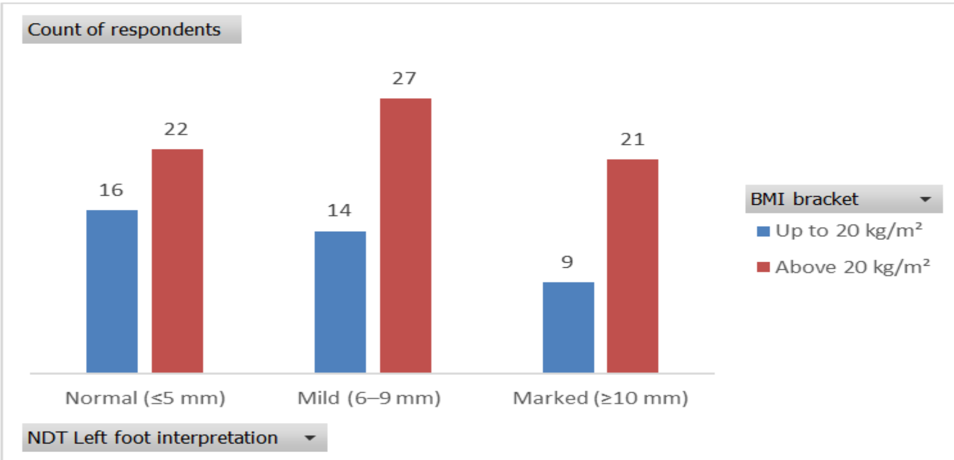
The Navicular Drop Test (NDT) results for the left foot show that out of 109 participants, 38 had a normal navicular drop (≤5 mm), 41 exhibited a mild drop (6–9 mm), and 30 showed a marked drop (≥10 mm). This distribution indicates that while a substantial proportion of participants maintain normal arch height, a slightly higher number experience mild to marked navicular drop, suggesting a tendency toward foot pronation or reduced medial longitudinal arch stability in the population.

Figure 4: Age-wise NDT left foot findings



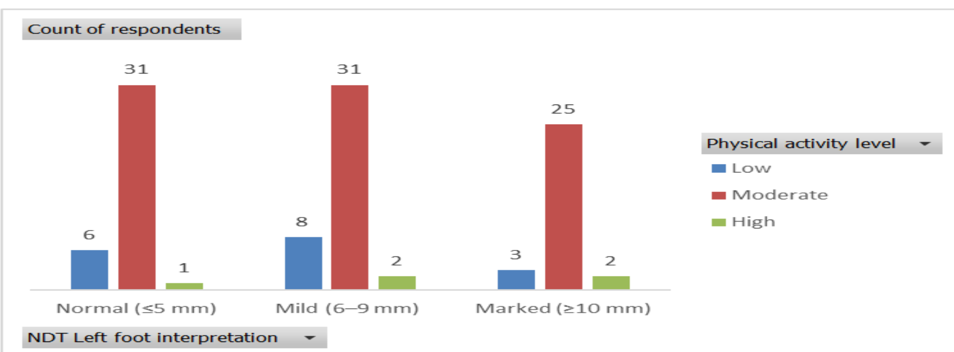
The Navicular Drop Test (NDT) results for the left foot, analyzed by age group, indicate that among participants up to 20 years, 5 had a normal navicular drop (≤5 mm), 4 exhibited a mild drop (6–9 mm), and 3 showed a marked drop (≥10 mm). In participants above 20 years, 33 demonstrated normal values, 37 had mild drop, and 27 presented marked drop. Overall, the data suggest that while normal navicular drop is more common in the older age group, mild to marked drop also occurs frequently, indicating that age may be associated with variability in medial longitudinal arch height, though a substantial number of older participants maintain normal foot posture.

Figure 5: BMI-wise NDT left foot findings



The Navicular Drop Test (NDT) results for the left foot, categorized by BMI, show that among participants with a BMI up to 20 kg/m², 16 had a normal navicular drop (≤5 mm), 14 exhibited mild drop (6–9 mm), and 9 showed marked drop (≥10 mm). In participants with a BMI above 20 kg/m², 22 were in the normal range, 27 had mild drop, and 21 presented marked drop. These findings suggest that higher BMI is associated with a greater tendency toward mild to marked navicular drop, indicating potential foot pronation or decreased medial longitudinal arch stability, whereas lower BMI participants are more likely to maintain normal foot posture.

Figure 6: Physical activity-wise NDT left foot findings



The Navicular Drop Test (NDT) results for the left foot, categorized by physical activity levels, indicate that among participants with low activity, 6 had a normal navicular drop (≤5 mm), 8 exhibited mild drop (6–9 mm), and 3 showed marked drop (≥10 mm). In the moderate activity group, the majority of participants fell within the normal (31), mild (31), and marked (25) categories. For participants with high activity, only a few showed normal (1), mild (2), or marked (2) navicular drop. Overall, participants with moderate physical activity are distributed across all NDT categories, while low activity participants tend to have slightly higher mild and marked drops. High activity participants are few but show a mix of outcomes, suggesting that moderate activity may be associated with variability in medial longitudinal arch stability, whereas low activity could be linked to slightly higher risk of foot pronation.

Table 1: Chi-Square Tests

Test Element	Pearson Chi-Square	p-value	Result
Age bracket * NDT foot	1.53	0.47	Reject Null Hypothesis (significant)
BMI * NDT foot	2.12	0.35	Reject Null Hypothesis (significant)
Dominant foot * NDT foot	14.33	0.01	Reject Null Hypothesis (significant)
Physical activity level * NDT foot	2.86	0.58	Reject Null Hypothesis (significant)
Current foot pain * NDT foot	2.00	0.37	Reject Null Hypothesis (significant)
Frequency of wearing flat soled footwear * NDT foot	3.81	0.70	Reject Null Hypothesis (significant)
Types of footwear usually worn * NDT foot	4.35	0.93	Reject Null Hypothesis (significant)
Hours of daily walking in regular footwear * NDT foot	5.32	0.50	Reject Null Hypothesis (significant)
Years of regular use of flat soled footwear * NDT foot	2.39	0.88	Reject Null Hypothesis (significant)
Use of orthotics / arch supports * NDT foot	0.91	0.64	Reject Null Hypothesis (significant)
Recurrent ankle discomfort * NDT foot	2.46	0.29	Reject Null Hypothesis (significant)
Age bracket * foot posture	0.06	0.81	Accept Null Hypothesis (insignificant)
BMI * foot posture	1.93	0.16	Reject Null Hypothesis (significant)
Dominant foot * foot posture	13.16	0.00	Reject Null Hypothesis (significant)
Physical activity level * foot posture	0.24	0.89	Accept Null Hypothesis (insignificant)
Current foot pain * foot posture	0.49	0.48	Reject Null Hypothesis (significant)
Frequency of wearing flat soled footwear * foot posture	2.86	0.41	Reject Null Hypothesis (significant)
Types of footwear usually worn * foot posture	1.00	0.96	Reject Null Hypothesis (significant)
Hours of daily walking in regular footwear * foot posture	1.79	0.62	Reject Null Hypothesis (significant)
Years of regular use of flat soled footwear * foot posture	1.24	0.74	Reject Null Hypothesis (significant)
Use of orthotics / arch supports * foot posture	0.38	0.54	Accept Null Hypothesis (insignificant)
Recurrent ankle discomfort * foot posture	0.00	0.98	Accept Null Hypothesis (insignificant)

SUMMARY OF KEY FINDINGS

- The study found a high prevalence of flatfoot and pronated foot posture among females using flat-soled footwear.
- Marked navicular drop was more common in the right foot (40.4%), while mild navicular drop was most common in the left foot, indicating reduced medial longitudinal arch stability.

- Flatfoot posture was more prevalent than normal posture in both feet, particularly in the right foot.
- Most participants were above 20 years of age, had BMI above 20 kg/m², and reported moderate physical activity levels.
- Right-foot dominance was the most common pattern and showed a statistically significant association with both NDT scores and foot posture ($p < 0.05$).
- Flat-soled footwear, especially slippers/chappals, was commonly used among participants, and prolonged walking duration was associated with greater navicular drop.
- Current foot pain and recurrent ankle discomfort were uncommon despite the high prevalence of altered foot posture.
- Correlation analysis showed strong positive relationships between right and left foot NDT and posture measures, indicating bilateral consistency.
- No statistically significant association was found between NDT outcomes and age, BMI, physical activity level, footwear habits, orthotic use, or recurrent ankle discomfort ($p > 0.05$).
- Overall findings suggest that flatfoot and pronated posture are common among females using flat-soled footwear, with dominant foot emerging as the most significant associated factor.

DISCUSSION

The present study evaluated the prevalence of flat feet among females and its association with flat-soled footwear use. The findings showed a high prevalence of altered foot posture among frequent users of unsupportive footwear.The foot's architecture is supported by three primary arches: the medial longitudinal arch, lateral longitudinal arch, and transverse arch. The medial longitudinal arch, formed by the calcaneus, talus, navicular, cuneiforms, and first three metatarsals, is critical for weight distribution and shock absorption, supported by the spring ligament [1][2]. The lateral longitudinal arch providesstability on the outer foot, while the transverse arch spans the tarsometatarsal area to maintain balance [1]. The foot is segmented into hindfoot, midfoot, and forefoot, with each contributing to gait, mobility, and adaptation to varied surfaces. Alterations in arch height or structure, influenced by genetics, body weight, or footwear, can result in conditions such as pes planus (flatfoot) or pes cavus (high arch), affecting posture, walking, and musculoskeletal function [3][7]. Flatfoot prevalence varies globally, with rates reported at 40.6% in Lahore, 14.4% in India, and 5.5% in China, and is more common in women due to structural differences and hormonal factors [8][9][10][11]. Dysfunction of the posterior tibial tendon (PTT) is a major contributor, as tendon weakening can collapse the medial arch, alter gait, and induce joint stress [13][17]. Obesity, age, and repeated injury further exacerbate foot deformities, increasing load on the arches and modifying biomechanics [18]. Diagnosis employs clinical observation, radiography, footprint analysis, ultrasound, CT, or MRI to assess arch integrity and foot function [19][20]. Flatfoot management depends on severity: early stages often respond to conservative interventions like orthotics and physical therapy, while advanced stages may require surgical correction, including osteotomies, arthrodesis, or tendon repair [21][25].

LIMITATIONS OF THE STUDY

The research methodology has several limitations that should be considered when interpreting the findings. First, the cross-sectional design prevents establishing causal relationships between flat-soled footwear use and the development of flat feet, as it only allows identification of associations at a single point in time without capturing long-term effects. Second, the study is limited to only two universities, Indus University and Jinnah Sindh Medical University, which may not represent the broader female student population in Karachi, thereby restricting generalizability. The short three-month data collection period may not account for seasonal variations in footwear use or the cumulative impact on foot posture. Although the sample size of 109 participants is statistically calculated, it may be insufficient to detect subtle variations in foot structure across different subgroups. The use of non-probability convenience sampling introduces selection bias, and reliance on self-reported data for footwear type, frequency, and duration may be prone to recall errors. Additionally, excluding participants with BMI above 29.9 kg/m² may underestimate flatfoot prevalence, as obesity is a known risk factor. The study also relies solely on the Navicular Drop Test without supplementary clinical or imaging assessments, potentially limiting diagnostic accuracy. Finally, lifestyle factors, physical activity, genetic predisposition, and previous minor injuries are not controlled, and the female-only sample limits applicability to males. These limitations suggest that results should be interpreted cautiously and highlight the need for longitudinal, multicenter, and more comprehensive studies.

FUTURE INVESTIGATE INQUIRY

To address the limitations identified in this study, several recommendations can be made for future research. First, adopting a longitudinal study design would allow researchers to observe changes in foot structure over time, helping establish causal relationships between prolonged flat-soled footwear use and the development of flat feet. Expanding the study population to include multiple universities and colleges across Karachi would improve the representativeness and generalizability of findings. Employing probability-based sampling methods, such as stratified or random sampling, would reduce selection bias and provide a more accurate estimate of flatfoot prevalence. Increasing the sample size could enhance statistical power and allow analysis of subgroups, such as differences based on BMI or age ranges. Incorporating objective diagnostic tools, such as radiographs, ultrasound, or 3D foot scans, alongside the Navicular Drop Test, would improve the accuracy and reliability of flatfoot assessment. Additionally, collecting comprehensive data on lifestyle factors, physical activity, previous minor injuries, and genetic predisposition would help control potential confounders. Finally, including both male and female participants in future studies would allow exploration of sex-specific risk factors and enhance applicability of results to the wider population.

CONCLUSION

The present study highlights the structural and functional significance of the foot's arches, particularly the medial longitudinal arch (MLA), which is crucial for weight distribution, shock absorption, and gait stability. The lateral longitudinal and transverse arches further contribute to balance and load transfer during movement. Alterations in arch structure, influenced by factors such as genetics, body weight, or prolonged use of flat-soled footwear, canresult in deformities like pes planus (flatfoot) or pes cavus (high arch), which affect posture, walking patterns, and musculoskeletal function. Epidemiological data show that flatfoot prevalence varies globally, with higher rates in women, potentially due to anatomical and hormonal differences. Dysfunction of the posterior tibial tendon (PTT), obesity, aging, and repeated injury are significant contributors to arch collapse and foot instability, altering biomechanics and increasing joint stress. Clinical assessment can include the Navicular Drop Test, radiography, footprint analysis, ultrasound, CT, or MRI, with management ranging from conservative interventions to surgical correction based on severity. In this study of 109 female participants, the majority were over 20 years old (89%) with higher BMI (64.2%), and right-foot dominance (77.1%). Navicular Drop Test scores indicated that 40.4% of right feet showed marked navicular drop, with flatfoot prevalence aligning with posture assessments. While foot pain, ankle discomfort, and orthotic usewere low, lifestyle factors and dominant foot significantly influenced navicular drop outcomes. Investigating flatfoot prevalence among females in Karachi is particularly significant due to widespread use of flat-soled footwear, extended periods of standing or commuting, and limited local research. Findings can inform preventive strategies, including education on proper footwear, early screening, ergonomic interventions, and guidance for healthcare professionals, ultimately improving foot health, mobility, and quality of life.

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