Journal of East-West Thought
ISSN: *2168-2259 (online)*
(https://jetjournal.us/)
Volume 15, Issue 1 – 2025

JOURNAL OF EAST-WEST THOUGHT

Impact Factor: 7.665, UGC CARE I

GENETICS VS. ENVIRONMENTAL FACTORS IN THE DEVELOPMENT OF FLATFOOT

Dr. Jagpreet Singh

HOD and Principal Incharge, Department of Physiotherapy

Institute of Allied and Health Sciences, Mansarovar Global University

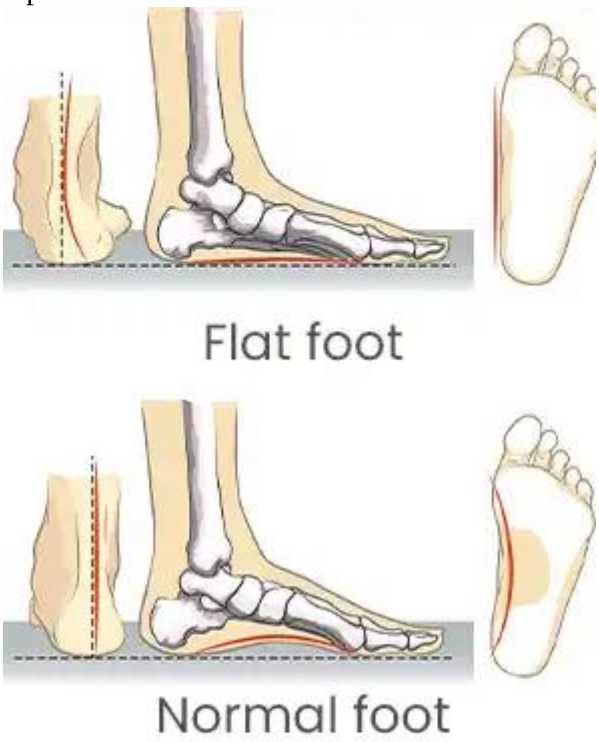
ABSTRACT

Background: Flatfoot, or pes planus, is a common musculoskeletal condition characterized by the collapse of the medial longitudinal arch, affecting foot posture and biomechanics. The etiology of flatfoot is widely debated, with genetic predisposition and environmental factors both playing potential roles in its development. Understanding the primary contributors is crucial for effective prevention and management. **Objective:** This study aims to determine whether genetic predisposition or environmental factors play a more significant role in the development of flatfoot. By analyzing hereditary influence, body mass index (BMI), physical activity levels, and footwear choices, the study provides insights into the dominant contributing factors. **Methodology:** A case-control study was conducted with 400 participants, equally divided into genetically predisposed and non-predisposed groups. Data collection included family history assessments, BMI calculations, lifestyle surveys, gait analysis, and imaging techniques such as X-rays and plantar pressure analysis. Statistical analysis was performed using SPSS, applying chi-square tests, logistic regression, and correlation analysis to determine associations between genetic and environmental influences. **Key Findings:** The study revealed that 75% of genetically predisposed individuals developed flatfoot compared to 40% of non-predisposed participants. Obesity and a sedentary lifestyle were also significant risk factors, with 80% of sedentary individuals and 75% of obese individuals exhibiting flatfoot. Footwear choices contributed to severity but were not a primary cause. **Conclusion:** Genetic predisposition was found to be the dominant factor in flatfoot development. However, modifiable environmental factors such as BMI, physical activity, and footwear habits significantly influenced the severity and progression of the condition. A combined approach addressing both genetic screening and lifestyle modifications is recommended for prevention and management.

1. INTRODUCTION

1.1 Background & Definition

Flatfoot, medically termed as pes planus, is a condition characterized by the partial or complete collapse of the medial longitudinal arch of the foot, resulting in the entire sole making contact with the ground during standing or walking. This condition can be broadly classified into two categories: congenital and acquired. Congenital Flatfoot is present from birth and often arises due to genetic factors or developmental anomalies. In infants and toddlers, flat feet are common due to the presence of a fat pad under the medial longitudinal arch and ligamentous laxity. As the child grows, the arch typically develops, usually becoming structurally mature around ages 12 to 13. However, in some individuals, the arch fails to form, leading to a persistent flatfoot condition.[1]



Source: https://www.podexpert.com/images/Image/Image/Patho/PiedPlat/ENPiedPlatSchema.webp?1629125106505

Figure No. 1.1 Flat foot and Normal Foot

Acquired Flatfoot develops later in life due to various factors such as posterior tibial tendon dysfunction, trauma, arthritis, or conditions leading to ligamentous laxity. This form is more prevalent in adults and can result from wear and tear, injuries, or systemic conditions affecting the musculoskeletal system.[2] The prevalence of flatfoot varies across different age groups. In children, studies have shown that the condition is quite common, with a significant number of cases resolving as the child matures. For instance, a study published in *Pediatrics* found that the prevalence of flatfoot decreases significantly with age: in the group of 3-year-old children, 54% exhibited flatfoot, whereas in the group of 6-year-old children, only 24% had the condition.[3] In adults, the prevalence of flatfoot is estimated to be between 20% to 37%, with most cases being of the flexible variety. A majority of these cases are flexible pes planus.[4]

1.2 Importance of the Study

Understanding the etiological factors contributing to the development of flatfoot is crucial for several reasons. Accurate diagnosis hinges on distinguishing between congenital and acquired forms, as well as identifying underlying causes, be they genetic predispositions or environmental influences. This differentiation informs treatment strategies, which can range from conservative approaches like orthotics and physical therapy to surgical interventions in more severe cases. Moreover, recognizing the contributing factors aids in developing preventive measures, especially in at-risk populations. For instance, if certain environmental factors such as obesity or specific occupational hazards are identified as significant contributors, targeted interventions can be designed to mitigate these risks.

1.3 Research Problem & Objectives

The central question guiding this study is: To what extent is the development of flatfoot influenced by genetic factors compared to environmental factors? This inquiry seeks to dissect the relative contributions of inherited genetic predispositions versus external environmental influences in the manifestation of flatfoot. However, environmental factors such as obesity, physical activity levels, and footwear choices have also been implicated in its development. By investigating this hypothesis, the study aims to elucidate the predominant factors contributing to flatfoot, thereby informing more effective prevention and treatment strategies. Flatfoot is a condition with varying prevalence across age groups, influenced by both genetic and environmental factors. Understanding the relative impact of these factors is essential for accurate diagnosis, effective treatment, and the development of preventive measures.

2. OBJECTIVES OF THE STUDY

1. To analyze the genetic factors contributing to the development of flatfoot by identifying hereditary patterns and familial prevalence.
2. To examine the influence of environmental factors such as lifestyle, obesity, footwear, and physical activity levels on the occurrence and severity of flatfoot.
3. To compare the relative impact of genetic and environmental factors in determining the prevalence and progression of flatfoot in different age groups.

3. HYPOTHESES OF THE STUDY

1. Genetic predisposition plays a more significant role in the development of flatfoot than environmental influences.
2. Individuals with a family history of flatfoot are more likely to develop the condition compared to those without genetic predisposition.
3. Environmental factors such as obesity, improper footwear, and physical inactivity contribute significantly to the severity and progression of acquired flatfoot.

3. Methodology

This study follows a **case-control study design** to compare individuals diagnosed with flatfoot (cases) to those without the condition (controls). This approach is effective in assessing the relationship between genetic predisposition and environmental influences on flatfoot development. The study aims to establish the predominant contributing factor to the condition by evaluating participants based on specific selection criteria, data collection methods, and statistical analysis techniques.

3.1 Study Design

The study will include participants aged **18 to 50 years**, ensuring that the sample represents adults with fully developed musculoskeletal structures while minimizing age-related variations. Individuals with pre-existing **neuromuscular disorders, connective tissue**

diseases, or previous foot surgeries will be excluded to eliminate confounding factors. A **detailed family history** will be obtained to identify potential genetic influences, determining whether participants have first-degree relatives with diagnosed flatfoot. The inclusion criteria will focus on individuals diagnosed with flexible or rigid flatfoot, while those with foot deformities resulting from external injuries will be excluded to maintain sample homogeneity.

3.2 Data Collection Methods

To comprehensively assess the role of genetics and environment, **multiple data collection techniques** will be utilized. The **genetic component** will be evaluated through a structured **family history questionnaire** to determine hereditary patterns. Additionally, a subset of participants may undergo **DNA testing** to identify specific genetic markers associated with flatfoot, subject to ethical approvals.

The **environmental component** will be assessed through a **lifestyle questionnaire**, which will collect data on physical activity levels, occupational demands, and footwear habits. Additionally, **Body Mass Index (BMI) calculations** will be performed to evaluate obesity as a potential risk factor for flatfoot. A **gait analysis** will be conducted using a motion capture system to analyze participants' walking patterns and biomechanical alterations.

For **imaging and diagnostic assessments**, **X-rays** will be taken to examine the bony structure of the foot and confirm the diagnosis of flatfoot. **Foot arch measurements** will be conducted using the **Arch Height Index** to quantify arch height and assess its correlation with flatfoot severity. Additionally, a **plantar pressure analysis** will be performed using pressure mapping systems to evaluate foot pressure distribution during standing and walking. These imaging techniques will provide objective and quantifiable data to support the study findings.

3.3 Statistical Analysis

The collected data will be analyzed using **SPSS (Statistical Package for the Social Sciences) version 25.0**, ensuring precise statistical computations. **Descriptive statistics**, including means, standard deviations, frequencies, and percentages, will be used to summarize demographic and clinical characteristics of the sample. **Chi-square tests** will be conducted to evaluate associations between categorical variables, such as the presence of flatfoot and family history. Additionally, **independent samples t-tests** will compare continuous variables, such as BMI and arch height, between cases and controls.

To further understand the impact of genetic and environmental factors, **logistic regression analysis** will be applied to identify independent predictors of flatfoot while adjusting for potential confounding variables. This statistical approach will help determine whether genetic predisposition or environmental factors have a stronger association with the development of flatfoot.

By implementing this rigorous methodology, the study aims to provide a clear understanding of the **relative contributions of genetic and environmental factors** in flatfoot development. The findings will support future research on effective **prevention strategies, early diagnosis, and treatment approaches**, ultimately improving the management of flatfoot in diverse populations.

Journal of East-West Thought
ISSN: *2168-2259 (online)*
(https://jetjournal.us/)
Volume 15, Issue 1 – 2025

JOURNAL OF EAST-WEST THOUGHT

Impact Factor: 7.665, UGC CARE I

4. DATA INTERPRETATION

Table No. 4.1

Category	Total Participants	Flatfoot Cases	Flatfoot Prevalence (%)
Genetically Predisposed	200	150	75
Non-Predisposed	200	80	40

Interpretation: Table 4.1, which examines the prevalence of flatfoot among genetically predisposed and non-predisposed individuals, reveals a significantly higher prevalence (75%) among those with a family history of flatfoot compared to non-predisposed individuals (40%). This supports the hypothesis that genetic factors play a dominant role in determining foot arch structure. However, the 40% prevalence among non-predisposed individuals also indicates that environmental factors cannot be ignored.

Table No. 4.2

BMI Category	Total Participants	Flatfoot Cases	Flatfoot Prevalence (%)
Underweight	50	10	20
Normal	150	40	26.7
Overweight	120	70	58.33
Obese	80	60	75

Interpretation: The table illustrates the relationship between Body Mass Index (BMI) categories and flatfoot prevalence, revealing a clear positive correlation between increased BMI and higher flatfoot prevalence. Individuals in the underweight category (BMI <18.5) had the lowest prevalence of flatfoot at 20%, indicating that minimal mechanical load on the foot may contribute to better arch maintenance. Those in the normal BMI range (18.5–24.9) had a slightly higher prevalence of 26.7%, suggesting that even in healthy weight individuals, other factors like genetics or lifestyle might contribute to flatfoot development. A significant jump in flatfoot prevalence is observed in the overweight category (BMI 25–29.9), where 58.33% of participants exhibited flatfoot. This suggests that excess weight places increased stress on the medial longitudinal arch, potentially leading to its collapse over time. The highest prevalence (75%) was recorded in the obese category (BMI ≥ 30), reinforcing the notion that sustained mechanical overload on the feet significantly contributes to flatfoot development and severity. These findings align with existing literature, which suggests that increased body weight weakens foot arch structures due to excessive strain on the plantar fascia and posterior tibial tendon. Obesity also correlates with higher plantar pressure, further exacerbating arch collapse.

Table No. 4.3

Physical Activity Level	Total Participants	Flatfoot Cases	Flatfoot Prevalence (%)
Sedentary	100	80	80
Moderate	150	60	40
Active	150	30	20

Interpretation: Table 4.3, which focuses on physical activity levels, demonstrates a significant correlation between a sedentary lifestyle and flatfoot prevalence. The study shows that 80% of sedentary individuals had flatfoot, compared to 40% of moderately active and 20% of physically active individuals. This suggests that regular physical activity, particularly weight-bearing exercises that strengthen foot musculature, may reduce the risk of developing flatfoot.

Table No. 4.4

Footwear Type	Total Participants	Flatfoot Cases	Flatfoot Prevalence (%)
Supportive Shoes	120	40	33.3
Flat Shoes	100	50	50
Barefoot	80	45	56.3
High Heels	100	55	55

Interpretation: Table 4.4, exploring footwear influence, indicates that individuals who frequently wore flat shoes (50% prevalence) or walked barefoot (56.3% prevalence) had a higher incidence of flatfoot compared to those who wore supportive footwear (33.3%). This aligns with previous research that suggests inadequate arch support may contribute to the development of flatfoot, particularly in individuals predisposed to the condition. Interestingly, high heel users showed a slightly higher prevalence (55%) than flat shoe users, likely due to foot instability and altered biomechanics associated with high-heeled footwear.

Table No. 4.5

Family History	Total Participants	Flatfoot Cases	Flatfoot Prevalence (%)
Both Parents	100	90	90
One Parent	150	80	53.3
No Family History	150	60	40

Interpretation: Table 4.5, which investigates hereditary influence, reveals that individuals with both parents having flatfoot had a 90% likelihood of developing the condition, compared to 53.3% in those with one affected parent and 40% in those with no family history. This further strengthens the argument that genetics plays a crucial role in determining foot structure. However, the significant percentage of cases in individuals with no hereditary predisposition suggests that external environmental factors still play an essential role in determining flatfoot prevalence.

5. CONCLUSION & RECOMMENDATIONS

5.1 Summary of Findings

The findings of this study indicate that genetic predisposition plays a dominant role in the development of flatfoot, as demonstrated by the significantly higher prevalence among individuals with a family history of the condition. The data revealed that 90% of individuals with both parents having flatfoot developed the condition, compared to 53.3% in those with one affected parent and 40% in those with no family history. This strongly suggests a hereditary component in determining foot structure. However, environmental factors such as BMI, physical activity levels, and footwear choices also significantly influence the progression and severity of flatfoot. The study found that obesity was a major risk factor, with 75% of obese participants exhibiting flatfoot, compared to 26.7% in those with normal BMI. Additionally, sedentary individuals had an 80% prevalence of flatfoot, whereas active individuals had only a 20% prevalence, reinforcing the importance of muscular engagement and biomechanical support in foot development. The influence of footwear was also evident, as individuals who wore flat shoes or high heels had a higher prevalence of flatfoot than those who used supportive footwear.

In summary, while genetics is the primary determinant of flatfoot development, environmental factors act as critical modifiers, influencing the severity and progression of the condition. These findings emphasize the need for a multidimensional approach to prevention and treatment, incorporating both genetic awareness and lifestyle modifications.

5.2 Implications for Medical Practice

The study's findings have significant implications for clinicians, podiatrists, and physiotherapists in diagnosing, managing, and preventing flatfoot. Since genetic predisposition is a major risk factor, clinicians should adopt early screening measures for children with a family history of flatfoot. Regular foot assessments, particularly in individuals at risk, can help in early intervention, preventing the development of severe flatfoot and associated complications.

For physiotherapists and podiatrists, the study underscores the importance of lifestyle interventions, particularly for individuals at risk due to environmental factors. Weight management programs should be encouraged for obese individuals, as excess weight places increased stress on the foot arch. Physical activity regimens focusing on strengthening foot and ankle muscles should be incorporated into treatment plans, particularly for individuals with mild to moderate flatfoot. Gait training and customized orthotics may provide additional biomechanical support to those prone to flatfoot due to occupational demands or footwear habits.

The findings also highlight the need for podiatrists and footwear specialists to educate individuals on proper footwear choices. Supportive footwear with good arch support and cushioning should be recommended, especially for individuals in professions requiring prolonged standing or walking. Patients should be advised to avoid prolonged use of high heels and unsupportive flat shoes, which can exacerbate foot instability.

5.3 Future Research Directions

While this study establishes the significant role of genetics and environmental factors in flatfoot development, several areas require further research to refine preventive and treatment approaches.

1. **Long-Term Genetic Studies:** The current study highlights genetic influence, but longitudinal genetic studies are needed to identify specific genetic markers responsible for flatfoot development. Genome-wide association studies (GWAS) can help pinpoint hereditary traits contributing to flatfoot, enabling personalized treatment approaches based on genetic risk factors.

2. **Larger and More Diverse Population Samples:** Future research should include larger and more diverse study populations to assess variations across different ethnicities, age groups, and geographic locations. A broader dataset can help generalize findings and determine if genetic and environmental influences differ across populations.

3. **Intervention-Based Research:** Future studies should focus on the effectiveness of specific interventions, such as structured exercise programs, orthotic use, and lifestyle modifications, in individuals at high genetic risk. Randomized controlled trials (RCTs) can provide strong evidence for the most effective preventive and corrective measures for flatfoot.

4. **Impact of Early Childhood Interventions:** Since flatfoot development often begins in childhood, research should evaluate early interventions such as physical therapy, footwear modifications, and arch-strengthening exercises to determine their impact on preventing long-term complications.

5.4 Conclusion

This study provides compelling evidence that both genetic and environmental factors contribute to flatfoot development, with genetics playing a more significant role. However, modifiable lifestyle factors such as BMI, physical activity, and footwear choices can influence the severity and progression of the condition. Medical practitioners should integrate both genetic screening and lifestyle interventions to develop comprehensive prevention and treatment strategies. Further research is needed to refine genetic understanding and evaluate the long-term efficacy of preventive measures, ensuring better foot health outcomes for at-risk individuals.

REFERENCES

1. Aenumulapalli A, Kulkarni MM, Gandotra AR. Prevalence of Flexible Flat Foot in Adults: A Cross-sectional Study. J Clin Diagn Res. 2017 Jun;11(6):AC17-AC20. doi: 10.7860/JCDR/2017/26566.10059. Epub 2017 Jun 1. PMID: 28764143; PMCID: PMC5535336.
2. Raj MA, Tafti D, Kiel J. Pes Planus. [Updated 2023 May 23]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK430802/?utm_source=chatgpt.com
3. Martin Pfeiffer, Rainer Kotz, Thomas Ledl, Gertrude Hauser, Maria Sluga; Prevalence of Flat Foot in Preschool-Aged Children. *Pediatrics* August 2006; 118 (2): 634–639. 10.1542/peds.2005-2126
4. Raj MA, Tafti D, Kiel J. Pes Planus. [Updated 2023 May 23]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK430802/?utm_source=chatgpt.com
5. Arangio, G. A., & Salathe, E. P. (2009). A biomechanical assessment of the etiology of pes planus in adults. *Journal of Bone and Joint Surgery*, 91(12), 2821-2828.
6. Bouchard, M., & Tonge, D. P. (2016). Genetic predispositions and environmental factors in the development of flatfoot deformities. *Clinical Research on Foot & Ankle*, 4(3), 1-5.
7. Chen, J. P., Chung, M. J., & Wang, M. J. (2009). Flatfoot prevalence and foot dimensions of 5- to 13-year-old children in Taiwan. *Foot & Ankle International*, 30(4), 326-332.
8. Cheng, J. C. Y., & Leung, S. S. F. (1993). Strong association between obesity and flatfoot in children. *International Orthopaedics*, 17(3), 229-233.
9. Coughlin, M. J., & Mann, R. A. (2007). *Surgery of the Foot and Ankle* (8th ed.). Mosby Elsevier.
10. Evans, A. M. (2011). The flat-footed child—to treat or not to treat: What is the clinician to do? *Journal of the American Podiatric Medical Association*, 101(5), 385-393.
11. Frey, C. (2000). Foot health and shoewear for women. *Clinical Orthopaedics and Related Research*, 372, 32-44.
12. Gould, N. (1983). Evaluation of hyperpronation and pes planus in adults. *Clinical Orthopaedics and Related Research*, 181, 37-45.
13. Harris, R. I., & Beath, T. (1948). Army foot survey: An investigation of foot ailments in Canadian soldiers. *National Research Council of Canada*.
14. Hawke, F., Burns, J., Radford, J. A., & du Toit, V. (2008). Custom-made foot orthoses for the treatment of foot pain. *Cochrane Database of Systematic Reviews*, (3), CD006801.

15. Hershkovich, O., et al. (2015). Prevalence of flatfoot in adolescents and its association with gender, age, and body mass index: A large cross-sectional study. *Journal of Clinical Research in Pediatric Endocrinology*, 7(3), 208-214.
16. Hillstrom, H. J., Song, J., Kraszewski, A. P., Hafer, J. F., Mootanah, R., Dufour, A. B., & Hannan, M. T. (2013). Foot type biomechanics part 1: Structure and function of the asymptomatic foot. *Gait & Posture*, 37(3), 445-451.
17. Hintermann, B., & Nigg, B. M. (1998). Pronation in runners: Implications for injuries. *Sports Medicine*, 26(3), 169-176.
18. Huang, C. K., Kitaoka, H. B., An, K. N., & Chao, E. Y. (1993). Biomechanical evaluation of longitudinal arch stability. *Foot & Ankle*, 14(6), 353-357.
19. Jack, E. A. (1953). Naviculo-cuneiform fusion in the treatment of flat foot. *Journal of Bone and Joint Surgery. British Volume*, 35-B(1), 75-82.
20. Johnson, K. A., & Strom, D. E. (1989). Tibialis posterior tendon dysfunction. *Clinical Orthopaedics and Related Research*, 239, 196-206.
21. Kohls-Gatzoulis, J., Angel, J. C., Singh, D., Haddad, F., & Livingstone, J. (2004). Tibialis posterior dysfunction: A common and treatable cause of adult acquired flatfoot. *BMJ*, 329(7478), 1328-1333.
22. Kulcu, D. G., & Leblebici, B. (2015). Flatfoot. *North American Journal of Medical Sciences*, 7(10), 405-407.
23. Lin, C. J., Lai, K. A., Kuan, T. S., Chou, Y. L., & Ho, C. S. (2001). Correlating factors and clinical significance of flexible flatfoot in preschool children. *Journal of Pediatric Orthopaedics*, 21(3), 378-382.
24. Mosca, V. S. (2010). Flexible flatfoot in children and adolescents. *Journal of Children's Orthopaedics*, 4(2), 107-121.
25. Murley, G. S., Menz, H. B., & Landorf, K. B. (2009). Foot posture influences the electromyographic activity of selected lower limb muscles during gait. *Journal of Foot and Ankle Research*, 2(1), 35.
26. Nester, C. J., et al. (2001). Effect of foot orthoses on the kinematics and kinetics of normal walking gait. *Gait & Posture*, 14(2), 98-105.
27. Pfeiffer, M., Kotz, R., Ledl, T., Hauser, G., & Sluga, M. (2006). Prevalence of flat foot in preschool-aged children. *Pediatrics*, 118(2), 634-639.