

Prevalence of Flat Foot in Bharatanatyam Dancers

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ABSTRACT

Aim: To study the prevalence of flat foot in Student Bharatanatyam dancers.

Objectives: To evaluate foot posture in Student Bharatanatyam dancers with foot posture index.

Methodology: The study was conducted on 223 participants who are practicing Bharatanatyam from 4 month up to 7 years. A written consent was taken and procedure was explained to subjects. Participants who had history of congenital lower limb deformity and lower limb injury in last 6 months, BMI >25 i.e. overweight were excluded from selection criteria. Foot structure was assessed with the help of Foot Posture Index 6 assessment chart which gives a detailed assessment for the changes in Medial longitudinal arch.

Results: The output of the assessment of FPI-6 claimed that out of 223 samples, 46.6% samples came under Highly Pronated category, 44.4% under pronated category and 9% in normal category. The involvement of left and right foot was found similar.

Conclusion: The outcome of the assessment revealed that there are 91.47% participants Bharatanatyam dancers have Flat foot which suggest Flat foot is highly prevalent in practicing Bharatanatyam dancers.

Clinical Implications: As Flat foot is prevalent amongst Bharatanatyam Dancers, with the help of Intrinsic foot muscle training, strengthening of foot muscles and use of proper orthotic foot wear that supports the arch can be worn to prevent flat foot issue.

Keywords: Flat foot, Bharatanatyam, Foot posture alignment, Functional changes, Medial longitudinal arch.

INTRODUCTION

Bharatanatyam, an esteemed form of Indian classical dance originating in Tamil Nadu, demands rigorous footwork, including standing, jumping, and foot tapping on hard surfaces.^[1] The hindfoot, or rearfoot, constitutes the posterior part of the foot, crucial for foot functioning, housing bones, joints, muscles, tendons, and ligaments. Normal feet possess longitudinal and transverse arches, with the medial longitudinal arch (MLA) being vital for weight distribution.^[13] The MLA's integrity

is supported by intrinsic foot muscles, ligaments, and bones, including the spring ligament and plantar aponeurosis.^{[11][4]} Secondary plantar flexors like Tibialis posterior and anterior, and various muscles aid in supporting the MLA during weight bearing. Pronation, the inward rolling of the foot, results in a flexible foot with decreased MLA height, often associated with flat feet and leading to foot problems, pain, and postural instability.^[14] Bharatanatyam dancers, due to repetitive movements, are prone to foot issues resulting in pain, ankle

problems, and arch changes, ultimately leading to repetitive injuries and arch flattening. Flattening of the arch can induce postural instability and balance issues.^[2] Repetitive injuries weaken foot muscles, causing arch collapse and decreased performance. The loss or collapse of the MLA due to repetitive injury leads to flat foot deformity, causing the foot to pronate and strain various foot bones, impacting walking and causing discomfort.^[11] Factors such as ligament laxity and excessive tension in calf muscles contribute to acquired flat foot deformity, commonly observed in Bharatanatyam dancers. Thus, maintaining foot health is crucial for dancers, especially those practicing Bharatanatyam, to prevent injuries, sustain performance, and ensure stability and balance.^[6] Flat feet, characterized by the absence of a visible arch, usually develop during childhood. Acquired flat foot, associated with conditions like midfoot laxity and forefoot abduction, results from an imbalance between forces that flatten the arch and those that support it.^[9] Bharatanatyam dancers, with their forceful foot tapping, are particularly susceptible to flat foot issues, experiencing symptoms like leg cramps, foot and leg muscle pain, and discomfort during walking^[5]. Compression of nerves due to overpronation can lead to symptoms akin to foot strain and heel pain.^[14] Understanding the causes and symptoms of flat foot is crucial for effective management and prevention of associated complications, ensuring dancers maintain optimal foot health and performance.

MATERIALS & METHODS

The study is conducted on the Prevalence of Flatfoot in Bharatanatyam Dancers who are training for more than 4 months up to 7 years. The study setting was conducted in Thane region by convenient. Sampling method and sampling size was 223. Dancers were selected from the age group of 15- to 25-year-old.^[16] The assessment was done using Foot Posture Index – 6 chart.^{[21][3]} Subjects were introduced to the topic and the procedure was

explained consent was taken from the participants^[12]. They were asked to stand for 2 minutes with double limb support looking forward and hands by the side. The foot posture assessment involves a systematic evaluation of various aspects of the foot's structure and alignment. Firstly, the talar head is palpated from an anterior view and scored based on predefined criteria. Following this, the supra and infra lateral malleolar curvatures are observed from a posterior view and rated accordingly. The calcaneal inversion and eversion are then assessed by drawing a line from the posterior part of the leg in reference to the tendoachilles, and noting the degree of inversion or eversion. Moving on, the Talonavicular joint is assessed from the medial side of the foot, and the congruence of the medial longitudinal arch is evaluated by observing the distance between the arch and the ground from the medial surface. Additionally, the abduction or adduction of the forefoot is observed from a posterior view at ground level. All assessments are conducted for both legs and graded according to a predefined assessment sheet. The total score is calculated, and based on reference values, the foot posture is categorized. Pronated postures are assigned positive values ranging from +6 to +9 for pronated and +10 to +12 for highly pronated feet, while supinated features are given negative values ranging from -1 to -12. A neutral foot should ideally have a final Foot Posture Index (FPI) aggregate score close to zero. Subsequently, the foot posture assessment data was collected and subjected to analysis to derive meaningful conclusions about the foot posture characteristics being studied. The study explains the interconnection between the lateral and medial longitudinal arches, crucial for foot support, stability, and shock absorption. While the lateral arch provides lateral stability and controls pronation and supination, the medial arch bears most of the body weight, especially during foot tapping and specific dance poses like *murumandi*. Repetitive tapping during practice can compromise the lateral arch,

resulting in excessive pronation and consequently placing increased stress on the medial arch. This imbalance may lead to muscular imbalances, increased load on medial structures, altered gait patterns, and joint alignment changes, ultimately affecting foot biomechanics and stability. Structurally, the integrity of the medial longitudinal arch is vital, involving bones like the metatarsals, cuneiforms, navicular, talus, and calcaneal bones, with the talus playing a central role in weight transmission. However, flat feet alter foot mechanics, leading to abnormal pronation or supination during walking, potentially causing overuse injuries and changes in joint alignment. The study utilized the Foot Posture Index-6 to assess foot posture, revealing a high prevalence of pronated and highly pronated feet among Bharatanatyam dancers, particularly with increasing years of practice. Although the research didn't establish a direct correlation between flat feet and age, it highlighted the impact of prolonged practice on foot arch deviation. In conclusion, the study underscores the significance of addressing foot imbalances and overuse issues among dancers through appropriate footwear, strengthening exercises, and biomechanical corrections to mitigate complications and maintain optimal foot health. Moreover, it emphasizes the need for early intervention to prevent long-term foot problems among dancers

RESULT

The gender distribution graph reveals a stark contrast between male and female representation, with 220 out of 223 samples being female, leaving only 3 samples identified as male. This highlights a significant predominance of females in the sample population. The distribution of samples across three age groups is as follows - 15-18, 19-21, and 22-25 years old. Among these groups, 56.1% of samples fall within the 15-18 age range, 23.3% within 19-21, and 20.6% within 22- 25, indicating a diverse representation across different age brackets. Furthermore, the study highlights the

duration of subjects' practice, with 34.1% practicing for 4 months to 2 years, 26.5% for 3 to 4 years, 25.6% for 5 to 6 years, and 13.9% for 6 to 7 years, showcasing varying levels of experience among participants.

Now, focusing on foot pronation of the subjects, it reveals that 44.4% of samples are categorized as pronated, 46.6% as highly pronated, and 9% as normal.

Table 1: Foot Posture Category

Foot posture category		
	Frequency	Percent
Highly Pronated	104	46.6
Pronated	99	44.4
Normal	20	9.0
Total	223	100.0

A closer examination within age groups unveils specific foot conditions: in the 15-18 group, 56 highly pronated feet, 57 pronated feet, and 12 normal feet are observed; in the 19-21 group, 25 highly pronated feet, 20 pronated feet, and 7 normal feet are noted; while in the 22-25 group, 23 highly pronated feet, 22 pronated feet, and 1 normal foot are identified.

Table 2: Foot Posture Index according to age

	Highly Pronated	Pronated	Normal
15-18 Age	56	57	12
19-21 Age	25	20	7
22-25 Age	23	22	1

The age-wise categorization does not provide any strong evidence to establish any claim. Thus, this provides a scope for further studies on the occurrence of Flat foot in specific age in the given population.

DISCUSSION

The Research was conducted to study the Prevalence of Flat foot in Bharatanatyam Dancers. It was seen that Bharatanatyam dancers requires lots of foot work like tapping of foot, long time standing during practicing years which leads to changes in foot posture causing the medial longitudinal arch to flatten. Flat foot also known as Pes planus is seen on the medial side of the foot characterized by lowering of the medial longitudinal arch. Eversion of the calcaneal bone, lowering navicular and talus bone with

abduction of forefeet from the posterior view.

The lateral longitudinal and the medial longitudinal arch of the foot are interconnected and work together to provide support, stability, and shock absorption. When you are standing, the weight of your body is distributed across both arches.

The lateral longitudinal arch, which runs along the outer edge of the foot, helps to provide lateral stability and support. It plays a role in controlling pronation and supination. When the lateral longitudinal arch is properly supported and functioning, it helps maintain the overall alignment and structure of the foot during *samapadam* pose. The medial longitudinal arch which is located at the inner edge of the foot, is typically higher and more pronounced than the lateral longitudinal arch. It is primarily responsible for bearing the majority of the body weight and providing shock absorption during tapping of foot^[11] and *murumandi* pose.

Due to constant tapping during practice the lateral longitudinal arch, such as weakness, collapse, or excessive rolling inwards which is pronation, it can impact the function of the medial longitudinal arch. A compromised lateral arch may lead to excessive stress on the medial arch, causing it to flatten or collapse which results in flat feet.

Repetitive movement like this strain the muscles, tendons, and ligaments of the foot, potentially impacting the lateral longitudinal arch. During standing, i.e., the *samapadam* stance and *murumandi* stance both arches work together to distribute the body's weight evenly across the foot, ensuring proper alignment and minimizing stress on the joints and soft tissues. The overuse or excessive training on the lateral longitudinal arch indirectly affects the medial longitudinal arch in the given ways such as:

1. **Compensatory Mechanisms:** This is when the lateral longitudinal arch is overused or stressed, it can lead to compensatory changes in foot mechanics. This may include excessive pronation or inward rolling of the foot

that tries to stabilize the body, which puts increased stress on the medial longitudinal arch.

2. **Muscular Imbalance:** Overuse of the lateral longitudinal arch while tapping the foot causes a muscular imbalance in the foot. Muscles that support the lateral arch become overactive or tight, while those supporting the medial arch may become weakened or stretched. This imbalance contributes to the collapse or flattening of the medial longitudinal arch over the time of practice period.
3. **Increased Load on Medial Structures:** As the lateral arch is overused, the body can be seen shifting more weight and pressure onto the medial side of the foot to compensate. Thus this increased load on the structures supporting the medial longitudinal arch leads to overuse injuries, such as plantar fasciitis or tendonitis, which further weakens the arches of the foot.
4. **Altered Gait Patterns:** Overuse of the lateral longitudinal arch may alter gait patterns, leading to abnormal foot movements and mechanics. These changes impact how forces are distributed across the foot, potentially placing undue stress on the medial longitudinal arch and its supporting structures.

Altered Foot Mechanics: Flat foot typically have a lower arch or no arch at all, which affects the weight distribution and force that are applied on the foot while walking. This altered foot structure leads to abnormal foot pronation or supination during the gait cycle like pronation in which the dancers with flat feet may exhibit excessive pronation, where the foot rolls inward excessively as it strikes the ground during walking. This causes the ankle to tilt inward and the arch to collapse eventually. Excessive pronation also leads to overuse injuries in the feet, ankles, knees, hips, and lower back. **Changes in Joint Alignment:** Flat feet can also lead to changes in the alignment of the lower extremity joints, including the ankles, knees, and hips. These changes affect the way forces are

transmitted through the body during walking, potentially leading to joint pain; Decreased shock absorption: The arch of the foot acts as a natural shock absorber during walking, helping to distribute impact forces and reduce stress on the lower extremity joints. In Bharatanatyam the dancers with flat foot, the reduced arch height compromises the foot's ability to absorb shock effectively, leading to increased stress on the joints and soft tissues.^[20]

Participants were collected by random sampling method. Study was conducted with consent of the subjects who were aware with the aims and objectives of the research. Foot Posture Index -6 which is assessment sheet used to evaluate the foot posture for flat foot, a study by Fatma A. Hegazy, "et al" to determine the Validity and diagnostic accuracy of FPI -6 using radiographic findings as gold standard to determine flexible flat foot between age 6-18^[21]. In this study 223 subjects were collected out of which 203 showed Flat foot and 20 shown normal foot.

In Prevalence of Flat foot in Bharatanatyam Dancers as foot work is an important demand during dance. Due to overuse of foot the arch gets affected hence we examined the subjects within 15-25-year-old as the medial longitudinal arch is completely formed by the age of 6 and is strongest till the age of 12. Participants having Congenital lower limb deformity^{[10][17]} lower limb injury within past 6 months^{[7][5]}, known case of diabetes^[10] and whose Body Mass Index (BMI) lies above >25 over weight category.^[19]

As there is significant bone loss with increasing age there is significant reduction in bone formation ^{[17][15]} Practicing years from 4 months to 7 years as its criteria for Amateur dancers.

As shown in table 1 in the assessment of FPI it was seen that 104 that is 46.6% participants are showing highly Pronated foot, 99 which is 44.4 % participants are having pronated foot and 20 which implicates 9% participants had normal foot which states that there are a greater number of participants having Flat foot with practicing years up to 7 years. The

participants having normal feet are the ones who have been practicing from 4 months to 1 year.

It is also seen that in the age 15-18 Age group there are total 103 participants in which 56 participants have Highly Pronated, 57 have Pronated foot and 12 are having normal foot. In 19-21 age group there 99 participants in which 25 are having highly pronated foot, 20 are having pronated and 7 are of normal foot.

In the age group of 22 to 25 age there are 46 participants in which 23 are having Highly Pronated 22 participants have pronated feet and 1 participant has a normal foot. However, this study does not show that flat foot is related with respect to age or but it can be seen that as the practicing years are increasing there is more deviation in the arch of the foot.

CONCLUSION

In this study the outcome of the assessment revealed that there are 91.47% participants i.e. 203: 223 indicates that Bharatanatyam dancers have Flat foot. In which 104 participants have highly Pronated foot, 99 pronated foot and 20 of normal foot. The involvement of left and right foot was found similar.

Declaration by Authors

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