

ASSESSMENT OF FOOT DEVIATIONS, FUNCTIONAL ACTIVITY, AND DYNAMIC BALANCE IN FEMALE KATHAK DANCERS

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Abstract

Kathak dancers are more susceptible to various foot posture deviations and injuries as this complex dance form emphasizes more on foot work putting substantial amount of stress on ankle and feet. This can lead to various problems related to ankle and foot such as pain, joint instability, flat feet, postural instability, soft tissue injuries, etc. These injuries have a bigger impact on their foot and ankle joint mobility, balance and functional performance affecting their ADLS and dance performance. Therefore there is need of detailed foot assessment of Kathak dancers in order to perceive the effect of dancing on their feet and to scale down its complications. Hence current study aimed to assess foot functional activity, foot deviations, dynamic balance and foot pain in female Kathak dancers. An observational study design 80 female Kathak dancers between age group of 18- 40 years were assessed for foot deviations, foot functional activity, dynamic balance and foot pain by Navicular drop test, foot function index, Y balance test and visual analogue scale respectively. Percentile analysis of Navicular drop test showed that a large population of kathak dancers (56.25%) has pronated feet. Foot functional activity showed that most of the population (86.25%) did not have any pain, disability and activity limitation leading to any foot function impairment, but among pronated foot type 11% population had mild impairment and 3.75% population moderate impairment. 25% population had below baseline score in Y balance test showing higher risk of losing balance and musculoskeletal injuries. People with foot deviations like supinated and pronated foot have high incidence rate of foot pain (36%) than normal foot (28%). Thus, current study concludes that Kathak dancers are more prone to have foot deviations leading to flat feet and it affects their foot function activity, balance causing foot pain and impairment. Study recommends that the dancers should be educated and trained about the foot problems associated with kathak dance and their prevention.

Keywords: *Kathak dancers, Navicular drop test, Y balance test, Foot function index, Visual analogue scale*

1. Introduction

One of the seven Indian classical dance forms "KATHAK" from Uttar Pradesh is characterized by fast twists, swift hand motions, storytelling, and quick, rhythmical complicated footwork. Kathak comprises of classical elements like nritta (pure dance), nritya (expressive dance) and natya. Kathak dancers utilize ghungroos (dancing bells) to keep their balance while performing spinning moves (chakkars) and providing rhythm to their performance in this extremely energetic dance style.^[1]

Footwork called "TATKAR" the base of kathak is of utmost importance which can be done in various tempos "laya" like slow (VILAMBIT), medium (MADHYA) and lastly fast (DRUT). For footwork, Kathak dancer use "V Stance" in which the dancers keep their feet in excessively turned out position due to which forefeet are turned out even more than the foot axis and it puts a lot of stress on the inner sides of the foot which results in the typical, functional hyperpronated foot.^[1] Dancers even adapt these unfavorable foot postures outside the dance class which may affect their foot function.

While practicing twists and turns (CHAKKARS) in various tempos with ankle bell (ghungroos) for numerous hours might put the foot in considerable pressure over time and might put the foot prone to major biomechanical changes. An ankle bell adds tension on the foot as each bell comprises of 150 ghungroos and they put 1.5 kg of weight on each ankle. Ghungroos might put excessive pressure on the leg as weight make it more difficult for the leg to lift the feet. and it can lead to muscle imbalance between agonist and antagonist muscles. Daily use of these ankle bells for years may overload the connective tissues of legs and can lead to overextension, tendon strain during the performance.^[1]

In the course of time, routinely execution of these movements for inexhaustible hours may lead to exposure of foot to substantial amount of stress abundant enough to make foot prone to significant biomechanical changes. Given that the medial longitudinal arch is durable, repeated pounding on hard floor causes it to permanently depress. Flat feet is the term for an excessively low medial longitudinal arched foot, which has been linked to abnormal tibialis posterior tendon sheath functions, including pain, damage to the joint, dynamic imbalance, and even stress fractures. The flexor digitorum longus and flexor hallucis longus muscles, which are used for tapping aids in the establishment of the medial longitudinal arch of the foot while supporting it. These muscles are also responsible for other foot movements necessary for the dance performance, such as big toe flexion and push-off power for jumps, etc.

Repetitive overuse of these may further give rise to inflammatory conditions such as dancer's tendinitis in addition to depression of medial arch.^[2] Furthermore, the impact produced by the Ground Reaction force over the foot during tapping is enhanced due to performance over hard cemented floors. Exposure of the legs to this impact for a period of time may result in joint injuries, changes in bony alignment of spine and lower extremities and many other joint problems.

A foot injury subsequently followed by an ankle injury and then up through kinetic chain may cause a dysfunction when a dancer is landing from a jump or a turn.^[3] The extreme strains that Kathak dancers undergo due to prolonged practice may have an impact on their performance and can lead to problems like heel pain, tenderness, trigger points, postural instability affecting their daily functional activity. The foot is essential for maintaining balance and any change to the medial longitudinal arch may result in abnormalities in the maintenance of balance.^[4] Postural-control techniques that are used to preserve balance may be impacted by even slight biomechanical changes in the support surface. Since the ground contact area varies depending on the kind of foot, different foot types—such as supinated and normal feet—may react differently to maintain the COG.^[5]

In conclusion, feet of Kathak dancers are exposed to enormous stresses in their daily routine and are more prone to musculoskeletal injuries which can likely affect their performance. Many studies have been performed on dancers of different western dance forms and athletes. But till date limited literature is available in relation to Kathak dance form even though it has been practiced since ages in India. Their highly complex dance forms may predispose them to abounding lower extremity injuries. Therefore, there is a need for the detailed foot assessment of the Kathak dancers in order to perceive the impact of dancing on their feet and to scale down its complications. This study will help in having a more clear insight about their foot problems so that in the future, more innovations can be brought into their prevention and treatment which may be appropriate to their profession and lifestyle. Hence current study aimed to assess foot functional activity, foot deviations, dynamic balance and foot pain in female Kathak dancers.

2. Objectives

- To assess foot deviations, foot functional activity, dynamic balance and foot pain in female Kathak dancers.
- To analyze impact of foot deviations on foot functional activity, dynamic balance and foot pain in female Kathak dancers.

3. Methodology

In this cross-sectional study design, 80 female Kathak dancers within age group of 18-40 years were selected by purposive sampling technique from various Kathak Dance Academy in and around PCMC, Pune.

Inclusion criteria:

- Females within age group of 18-40 years.
- Duration: 2 or more than 2 years of dancing.
- Normal BMI- 18.5-24.9 Kg/m².
- Subjects willing to participate in the study.

Exclusion criteria:

- Ankle or knee joint instability or injury in past 1 year
- Surgery of lower limb, spine and abdomen in last 3 months.
- Subjects with neurological dysfunction, musculoskeletal dysfunction, psychiatric conditions.

4. PROCEDURE

After obtaining ethical approval from the Institutional Ethics Committee, 80 female Kathak dancers were selected according to the inclusion and exclusion criteria. The aim and method of the study was explained and informed written consent was taken from all participants. All the participants were assessed for foot deviations, foot functional activity, dynamic balance and foot pain by Navicular drop test, foot function index, Y balance test and visual analogue scale respectively.

1. Foot function index-

The foot function index (FFI) consisted of 23 self-reported items divided into 3 subcategories on the basis of patient values: pain, disability, and activity limitation. The individual scored each question on a scale from 0 (no pain or difficulty) to 10 (worst pain imaginable or so difficult it requires help), which best described their foot over the past week. Both total and subcategory scores were calculated. ^[6]

2. Navicular drop test:

Navicular Drop test was used to measure Medial Longitudinal Arch Height. Individual subject was placed in a sitting position with their feet flat on a firm surface with the hip and knees flexed to 90 degree and ankle joints in neutral position. Subtalar neutral position was achieved when talar depressions were equal on medial and lateral side of the ankle. The examiner took measurement by kneeling in front of the subject. While the subject was still in a sitting position, a dot was marked on the navicular tuberosity. An index card was placed and was marked at the level of navicular tuberosity. Then the subject was asked to bear an equal weight on both the foot and was asked to stand. The new position of navicular tuberosity was marked on index card. The difference was noted in the units of millimetre. Both right and left feet were assessed. ^[7]



Figure 1. Navicular Drop Test Start And End Position

3. Y balance test:

The Y Balance Test (YBT) was a simple yet reliable technique for measuring dynamic balance. The individual was made to balance on one leg while reaching as far as possible with the other leg in toe touch with 3 trials in three different directions: anterior, posterolateral, and posteromedial. The individual was also informed not to keep their leg down during the trial as it may lead to start the test again. As a result, this test was used to assess the individual's strength, stability, and balance in a variety of directions. ^[8]



Figure 2. Y Balance Test

4. Visual Analogue Scale

VAS was utilized as a subjective self-reported scale for description of pain. It consisted of a straight horizontal line of fixed length, typically 100 mm, with the ends representing the extreme limits of the parameter being measured, such as symptoms, pain, or health. The individual was explained about the scale on 0 being no pain along with and 10 being extreme pain. Pain was recorded only of those individuals who complained of foot pain. Mohammad Anwar Hosain et studied Validity And Reliability Of Visual Analogue Scale (VAS) For Pain Management which showed a good inter-rater and intra-rater reliability of scale.^[9]

5. RESULTS

The data was analyzed using Microsoft Office Excel 2010. Mean and Standard deviations were analyzed for age, BMI and quantitative measurements with 95% confidence interval.

Table 1. Mean And SD Of Variables

Sr. No.	Outcome Measures	Mean	+/-SD
1.	Age	25.55	+/-8.322
2.	BMI	22.65	+/-2.25
3.	Foot Function Index	20.056	+/-10.154
4.	Navicular Drop test (Right)	10.562	+/-1.088
5.	Navicular Drop test (Left)	10.562	+/-1.088
6.	Y Balance Test (Right)	89.5	+/-6.582
7.	Y Balance Test (Left)	89.8	+/-6.836

Table 1 represents mean and standard deviation values for age, BMI, Foot Function Index, Navicular drop test and Y balance test for right and left.

Table 2. Age Distribution Of Study Population

	AGE				
Years	1	23-26	27-30	31-35	36-40
Participants	48	08	01	06	17
Percentage	56.7%	26.9%	1.5%	4.5%	10.4%

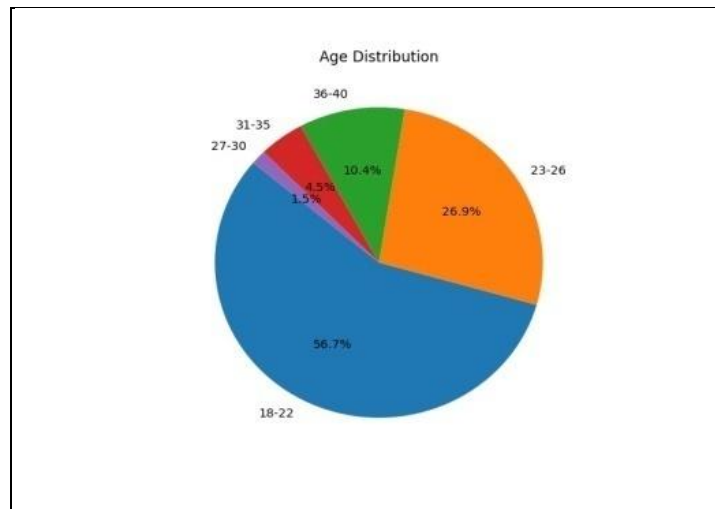


Figure 3. Age Distribution Of Study Population

Table no. 2 and Figure no.3 represents age wise distribution among study population which showed that maximum population belonging to age group 18-22 years with 48 participants is 56.7% and minimum population belonging to age group 27-30 years with 1 participant is 1.5%.

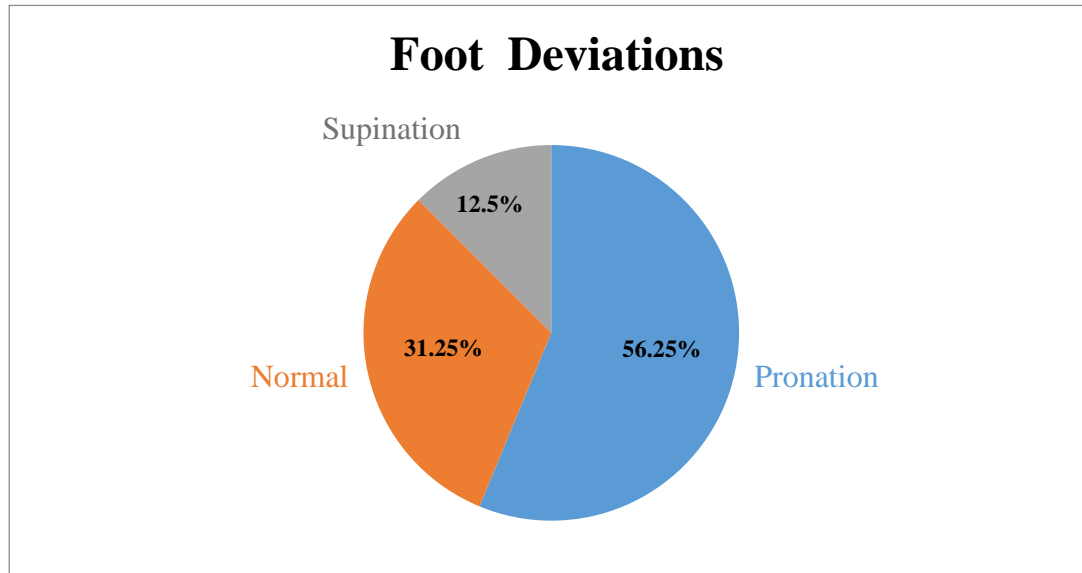


Figure 4. Foot Deviations In Study Population

Figure No.4 represents foot deviations among study population which showed that a maximum population that is 45 dancers had pronated feet (56.25%), 25 dancers had normal foot type (31.25%) and minimum population - 10 dancers had supinated feet (12.5%).

Table 3.Representation Of Foot Functional Activity Among Different Foot Types

Foot Function Index	Total No. of participants	No impairment <25	Mild impairment 25 – 30	Moderate impairment 50 - 75	Severe impairment >75
No. of participants	80	69	8	3	0
Normal Foot type	25	24	1	0	0
Pronated Foot type	45	37	5	3	0
Supinated Foot type	10	9	1	0	0

Table No.3 represents foot functional activity among study population which showed that most of the population (86.25%) did not have any pain, disability and activity limitation leading to any foot function impairment, whereas 1% population had mild impairment and 3.75% had moderate impairment. 4% population among normal foot type had mild impairment, among pronated foot type 11% population had mild impairment and 3.75% population moderate impairment and 10% population among supinated foot type had mild impairment.

Table 4.Representation Of Dynamic Balance Among Different Foot Types For Right And Left Leg

Y Balance Test	Total No. of participants	Risk of injury <89%		Baseline 89% - 94%		No risk >94%	
No. of participants	80	20		27		33	
		RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT
Normal Foot type	25	4	3	11	10	11	11
Pronated Foot type	45	17	15	11	15	16	16
Supinated Foot type	10	1	2	3	3	6	5

Table No.4 represents Dynamic balance among different foot types for right and left leg stating that maximum study population 41.25% had good score in YBT and having no risk of losing balance and injuries. 33.75% population had baseline score in YBT and 25% population had below baseline score showing that they are more prone to losing balance and musculoskeletal injuries. 12% population with normal foot type, 35.55% with pronated foot type and 10% with supinated foot type had below baseline score. People with pronated foot type showed higher risk of losing balance and musculoskeletal injuries.

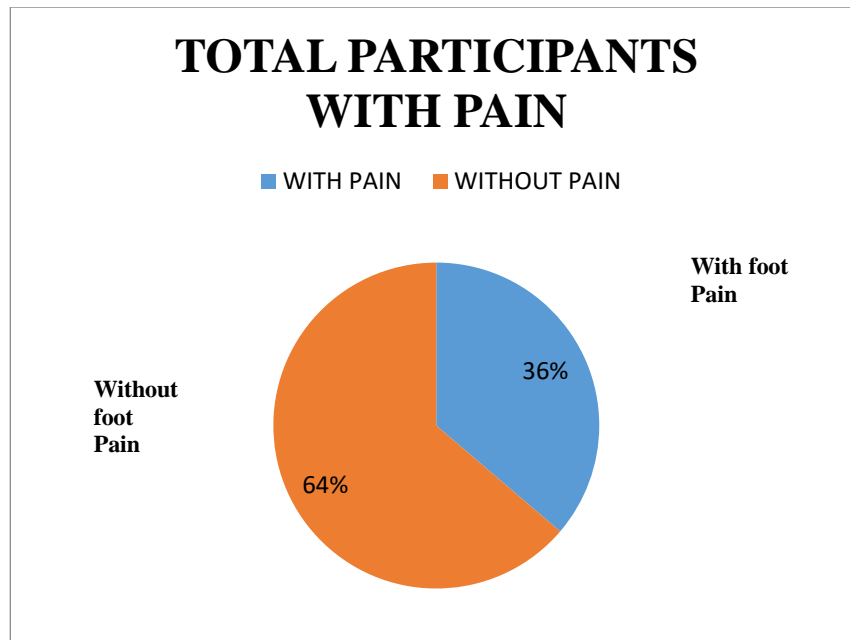


Figure 5. Foot Pain Among Study Population

Figure no.5 represents analysis of foot pain in study population showing that maximum population – 64% did not have any foot pain and 36% population presented with foot pain.

Table 5. Representation Of Foot Pain Among Different Foot Types

Characteristic		Foot Types With Pain		
		Normal	Pronated	Supinated
Total Participants	80	25	45	10
Participants with Pain	29	7	18	4
Percentage	36.50%	28%	36%	36%

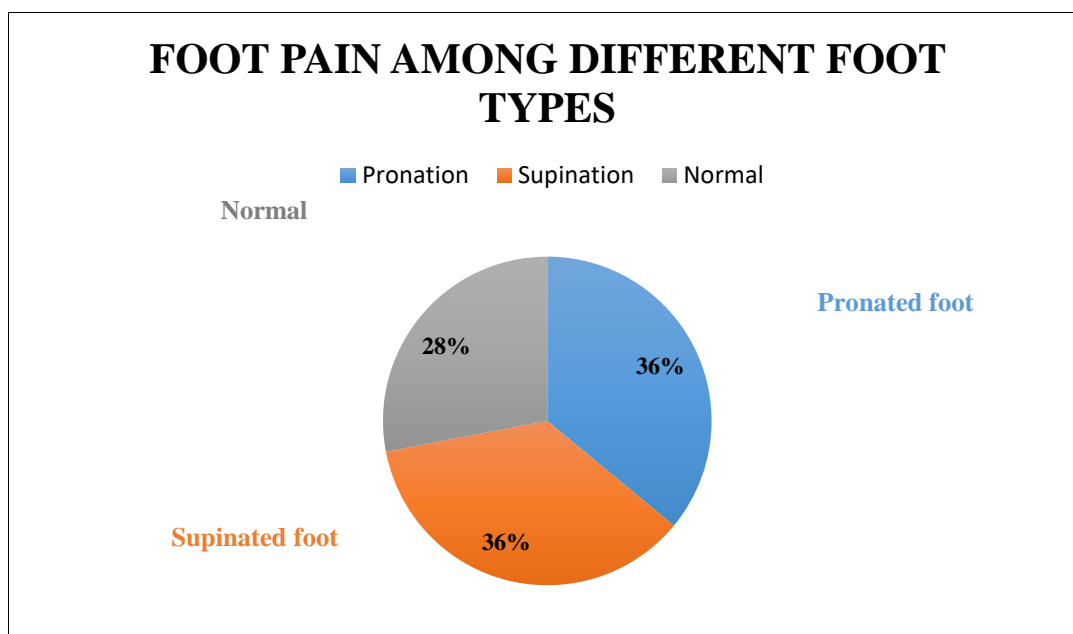


Figure 6. Foot Pain Among Different Foot Types

Table no.5 and Figure no.6 represents distribution of study population with foot pain among different foot types. It showed that 36.5% of total population reported to have foot pain. People with deviation in foot type such as supinated and pronated foot have high incidence rate of foot pain (36%) than normal foot (28%).

Table 6. Age Distribution Of Study Population With Foot Pain

Age Distribution	18-22	23-26	27-30	31-35	36-40
No. Of Participants	48	8	1	6	17
Participants With Pain	10	2	1	2	15
Percentage	21%	25%	100%	33%	88%

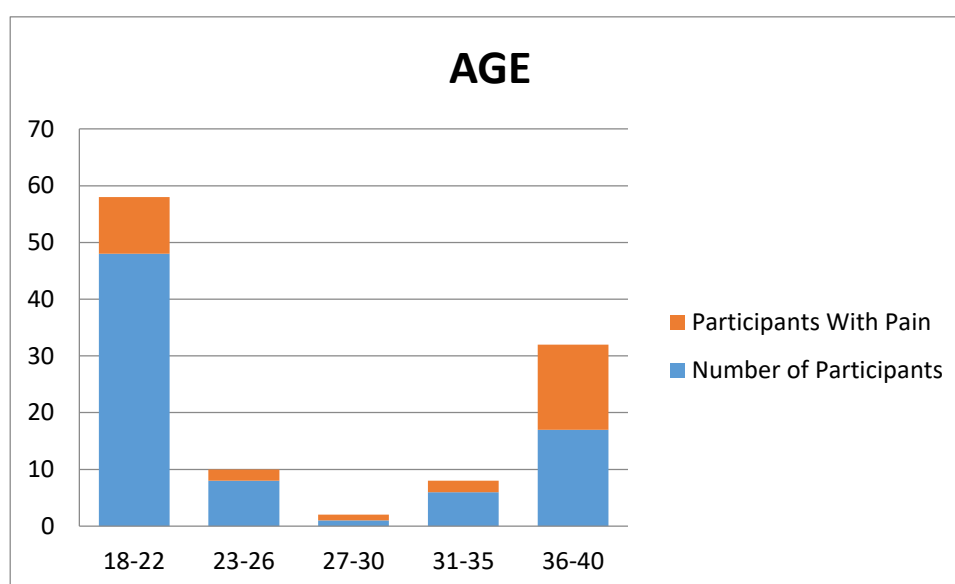


Figure 7. Age Wise Distribution Of Study Population With Foot Pain

Table No.6 and Figure 7 represents age distribution of study population with foot pain which showed that maximum people from age group of 36 to 40 years reported of foot pain (88%) and minimum people from age group 18 to 22 years reported of foot pain (21%). It supports that as age progresses kathak dancers tend to have foot pain.

6. DISCUSSION

The objective of the study was to assess foot deviations, foot functional activity, foot pain and dynamic balance in female Kathak dancers and analyze the impact of foot deviations on foot functional activity, foot pain and dynamic balance in female Kathak dancers. The study was conducted on 80 female Kathak dancers between the ages of 18-40 years with mean age of the study population was 25.55 with SD +/-8.322.

Zuil-Escobar Jc et studied Medial Longitudinal Arch: Accuracy, Reliability, and Correlation Between Navicular Drop Test and Footprint Parameters Both intrarater and interrater reliability were excellent for all the parameters evaluated (intraclass correlation coefficients > 0.880).^[4]

According to Elly Budiman-Mak et al. studied a review of foot function and foot function index in which test-retest reliability of the FFI total and sub-scale scores ranged from 0.87 to 0.69. Internal consistency ranged from 0.96 to 0.73.^[6] Along with that Yousef Alshehre et al. studied Reliability and Validity of the Y-balance Test in Young Adults with Chronic Low Back Pain with excellent inter-rater reliability, with intraclass correlation coefficients ranging from 0.99 to 1.0.^[8]

In our study foot postural deviations in the Kathak dancers were assessed using Navicular drop test which showed alterations in the Medial Longitudinal Arch Height. Navicular drop test helps to assess height of medial longitudinal arch and to classify foot type as neutral, pronated, or supinated accordingly. In current study, out of 80 Kathak dancers, 45 dancers had flat feet (56.25%), 25 dancers had normal foot type (31.25%) and 10 dancers were with supinated feet (12.5%). Kathak dance form interferes with the growth and development of the foot's arches because the majority of dancers began their training at a very young age and most issues develop over time.^[10]

Kathak dancers maintain "V Stance" in which they keep their feet in excessively turned out position due to which forefeet are turned out even more than the foot axis placing foot into pronation. This puts enormous stress on the inner sides of the foot which results in the typical, functional hyperpronated foot with repetition, stabilizing or fixing itself in that posture. Over time, the dancers form a habit of keeping their feet in this abducted position even when they are not in the dance studio, doing everyday tasks like walking, standing, and so forth. This leads the foot's position to be more pronated during both static and dynamic weight bearing.^[1] The observed decrease in the medial longitudinal arch and flattening of the foot may be attributed to the repetitive tapping on the floor during the Kathak dance performance. The medial arch is weakened by excessive tapping and usage of the intrinsic muscles, which causes the foot to flatten and deviate toward a pronated position.^[1]

Another factor that could contribute to the flattening of foot is practicing over hard floors.^[1] Kathak dancers need powerful contractions of foot's invertor muscles to have controlled motion at the foot on the hard floor. But with repetitive tapping and overuse of intrinsic muscles the Medial Longitudinal arch flattens and leads to changes towards pronation.^[10] When medial longitudinal arch drops, talus becomes misaligned because of its prime location within the medial arch. In the sagittal plane, the subtalar joint axis dips below 45 degree, causing the foot to pronate excessively and the rear foot to abduct and evert more. This might also disturb the other tarsal bones, which would cause the foot to pronate excessively.^[1] As suggested in a study done by Eustace et al. in 1994, height of the medial longitudinal arch overweighs all the other factors which can lead to metatarsal pronation. Thus, the pronation at foot observed among the Kathak dancers in the current study could be related to the flattening observed at the medial arch.^[11]

Foot functional activity was assessed by foot function index which showed that most of the population (86%) did not have any pain, disability and activity limitation leading to any foot function impairment; whereas 1% population had mild impairment and 3.75% had moderate impairment. We further analyzed impact of different foot types on foot function which showed that 4% population among normal foot type had mild impairment, among pronated foot type 11% population had mild impairment and 3.75% population moderate impairment and 10% population among supinated foot type had mild impairment.

Kathak dancers with pronated foot have high incidence of impaired foot function. Variations in the kinematics and functions of the foot are linked to altered foot postures and the resulting risk of injury.^[3] The extreme strains that Kathak dancers undergo result into heel pain, tenderness, trigger points, postural instability affecting their daily functional activity.^[1] Mal-alignment-related biomechanical alterations may have an impact on joint loads, muscle mechanical efficiency, proprioceptive orientation, altering neuromuscular function^[3] and can cause foot function impairment. Based on research by Pavana et al. where they determined if foot deviations and related foot injuries have any impact on foot function where they observed that pain experienced by dancers restricted their daily activities and hampered their dance performance.^[12]

In our study dynamic balance was assessed using Y balance test to check if foot deviations affect balance as Kathak dancers have various types of footwork due to which instability can occur. Results stated that maximum study population (41.25%) had good score in YBT and having no risk of losing balance and injuries. 33.75% population had baseline score in YBT and 25% population had below baseline score showing that they are more prone to losing balance and at risk of musculoskeletal injuries. People with pronated foot type showed higher risk of losing balance and musculoskeletal injuries as 35.55% with pronated foot type, 12% population with normal foot type, and 10% with supinated foot type had below baseline score. Postural control techniques that are used to preserve balance may be impacted by even slight biomechanical changes in the support surface. Since the ground contact area varies depending on the kind of foot, different foot types—such as supinated and normal feet—may react differently to maintain the COG. Flattening of the medial arch might put more strain on the neuromuscular system in order to keep the foot stable and maintain an upright posture.^[13]

Karen P. Cote et where they determined if supinated and pronated foot types influence measures of static and dynamic balance with star execution balance test where they found out that there was no significant relation in foot type and static balance but there was difficulty in reaching to a certain direction in dynamic balance testing like the supinated foot had a significant difference in the lateral direction.^[14]

Pain assessment indicates that 36.5% population suffered from foot pain and it was more common among the participants with pronated and supinated foot type (36%) than normal foot type (28%). Also foot pain was more common as age progressed because maximum population (88%) from age group of 36 to 40 years had foot pain and younger age group of 18 to 22 years showed pain among only 21% population.

With progressing age we suspect to have degenerative changes at ankle and small joints of foot which may lead to foot pain along with that reason for foot pain. The overuse of plantar flexors, dorsiflexors, and foot invertors from the repetitive foot postures on hard surfaces lead to ankle and foot pain. Muscle exertion transfers all of the tension to the bones causing tendonitis and periosteitis.^[1] Flat foot has been documented to induce abnormal functioning of the tendon sheath of the tibialis posterior, causing pain, joint damage, and even stress fracture. The main injuries are caused by altered ankle-foot complex biomechanics, which affect foot weight bearing and cause pain and discomfort in the foot and other lower limb joints because of synchrony in their biomechanics affecting ADLS, including walking, standing for extended periods of time, postural abnormalities, and abnormal gait in all age groups.^[4]

Hence we can conclude that Kathak dancers are more prone to have foot deviation such as flat feet and it affects their foot function activity, balance causing foot pain and impairment. Study recommends that the dancers should be educated and trained about the foot problems associated with kathak dance and their prevention.

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