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FOOT POSTURAL DEVIATIONS IN FEMALE KATHAK DANCERS

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ABSTRACT

Background: Kathak is a very complex dance form in which greater emphasis is laid on foot work thus putting substantial amount of stress over the feet. The purpose of this study was to investigate the foot postural deviations amongst the Kathak dancers.

Methods: Screening of 40 Female Kathak Dancers was done for the study from Department of Dance, Punjabi University, Patiala on the basis of inclusion criteria. Subjects were assessed for Postural deviations via. Foot Posture Index, Medial Longitudinal Arch Angle, Navicular Drop, Rearfoot angle and Forefoot angle.

Results: Percentile analysis of Foot Posture index scores suggested that a large population of kathak dancers (approx 92.5 %) have pronated feet. Most of the Kathak dancers showed increase in Rearfoot angle (approx. 90%), Forefoot angle (approx.75%) and Navicular drop (approx. 97%) and decrease in Medial Longitudinal Arch angle (approx. 95%). Analysis of Coefficient of Correlation suggested a significant positive relationship of Foot Posture Index scores with Rearfoot angle ($r = 0.40$, $p = 0.0087$), Navicular Drop ($r = 0.62$, $p = < 0.0001$) and Forefoot angle ($r = 0.51$, $p = 0.0007$) and a significant negative correlation with Medial Longitudinal Arch angle ($r = -0.42$, $p = 0.0059$).

Conclusion: From the observations, it can be concluded that with time kathak dancers start developing certain Postural Deviations at Foot which can lead to hyperpronation. These changes if not treated on time may lead to various degenerative changes in the Foot and Ankle thus leading to the instabilities and can also make them susceptible to foot and ankle injuries, shin pain, etc. Thus, the study recommends that the dancers should be educated and trained about the foot problems associated with kathak dance and their prevention.

Keywords: Kathak dance, complex postures, Foot problems, Foot Postural deviations, Biomechanical Changes, Assessment.

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INTRODUCTION

'Kathaka' is the art of storytelling and conveying it to the audience in a vivid and entertaining manner. It has all the classical elements such as nritta (pure dance), nritya (expressive), and natya. It is a highly spirited dance form in which the dancers make use of *ghungroos* (dance bells) for maintaining body balance while performing spinning movements (*chakkars*) and giving rhythm to their performance, facial muscles for expressing their emotions (*abhinaya*) and arms and feet for the formation of statuesque poses called *mudras* [1]. In a nutshell, Kathak is a stimulus that affects the body in its entirety.

'Chari Bheda' is an essential component of the Kathak dance which refers to the compositions of various kinds of foot movements performed during the dance. The *tatkar* (fast footwork) helps in releasing the anger and tension [1]. The 'tala' is taken up by the dancer for detailed rendering through a breathtaking array of rhythmic patterns, first at a slow tempo ('vilambit'), then at a medium tempo ('madhya laya') and finally at the fast tempo ('drut') [2]. This ends with a dramatic climax.

While enacting Kathak dance, the dancers also need to execute various swirling movements at the body with a warp speed. These swirls, also known as pirouettes have to be concluded with formation of complex *mudras* [3]. The number of these speedy pirouettes in a performance can range from one to 108, commonly arranged in multiples of three [4]. 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.

The normal stance position of Kathak dancers during the performance consists of overly turning out the feet. The forefeet are turned out even further than the foot axis, putting an additional strain on the inner side of the foot. This results in the typical, functional hyperpronated foot. Even outside the dance studio, dancers tend to maintain this disadvantageous position thus encouraging the unspiralling of the foot [5].

Likewise, repetitive pounding of the foot over the floor makes the medial arch to depress permanently as the medial arch is extremely resilient. Tapping makes use of flexor hallucis longus and flexor digitorum longus muscles which helps in the formation of Medial Longitudinal arch at foot while providing support to it [6]. These muscles are also liable for other foot movements required for the dance performance such as flexion of the big toe, 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 [7]. 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.

Moreover presence of ankle bells (*ghungroos*) further adds to the stress experienced by the foot. Each ankle bell consists of about 150 *ghungroos* contributing to about 1.5 kg of weight on each ankle [3]. With time, daily use of these ankle bells may overload the connective tissues of legs and can lead to overextension, tendon strain and other connective tissue injuries during the performance. The leg muscles have to work harder to lift the feet when weights are present due to which a muscle imbalance between the agonists and the antagonists may occur at a faster pace.

It can be figured out that the foot of the Kathak dancers is being continuously exposed to number of stresses in their daily routine due to which foot adapts itself to compensate these forces by bringing out certain alterations in its mechanics.

Indian classical dance is getting exposed to newer confrontations day by day for achieving the pinnacle of success in the present world. These challenges require the dancers to work with robust intensity like an athlete and to focus like an artist for bringing perfection in each and every component in their performance [8].

Kathak dancers are exposed to enormous stresses at foot which can likely affect their performance. Many studies have been performed on dancers of different western dance forms like ballet, hip-hop, jazz, and many other Indian classical forms such as Bharatanatyam, etc. Numerous studies have been done on athletes and sports persons. But till date no satisfactory literature is present in relation to Kathak dance form. Their highly complex dance forms may predispose them to abounding lower extremity injuries. Therefore, there is a need for the detailed assessment of the Kathak dancers in order to perceive the effect 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 treatment which may be appropriate to their profession and lifestyle.

METHOD

Study design

An observatory study was performed on the Kathak dancers which focused on analyzing various postural deviations at foot among these dancers and also made an approach to determine the relationship between them. Screening of 40 Female Kathak Dancers was done for the study from Department of Dance, Punjabi University, Patiala on the basis of inclusion criteria. Female Kathak dancers from the age group of 18-35 yrs with minimum dancing experience of 2 years were taken for the study. Subjects with a history of any recent surgery at lower limbs, any neurological deficit, or any congenital deformity which may affect the functionality of the lower limbs were excluded. Dancers who were professionally inculcated in outdoor sports such as Football, Athletics, Badminton, Soccer, Judo, etc were excluded from the study in order to restrain the results of the study from any error.

Procedure

The various instruments which were required during the study were Universal Goniometer, Marker, Foot Stepper, Index Card and Ruler. Postural Deviations at foot were assessed with the help of Foot Posture Index. Rearfoot angle, Forefoot angle, Navicular Drop and Medial Longitudinal Arch angle were measured to quantify the biomechanical deviations occurring at the foot.

For determining the scores of Foot Posture Index, the subjects were required to stand still while keeping their lower limbs in the relaxed stance position on the floor. They were asked not to swivel to see what is happening for them, as this may significantly affect their foot posture. After positioning and instructing the patient, all the 6 components of the Foot Posture Index (Talar Head palpation, Supra and Infra lateral malleolar curvature, Calcaneal frontal position, Prominence in the region of Talonavicular joint, Congruence of the Medial Longitudinal Arch and Abduction/Adduction of the Forefoot on the Rearfoot) were assessed according to the predefined criterion. Each of the observations/components were graded as 0 for neutral, -1 or -2 for clear signs of supination and +1 or +2 for signs of pronation according to severity of condition.[9] The final score was a whole number between -12 to +12. Inter-tester reliability for this index ranges from 0.62 to 0.91 and Intra-tester reliability ranges from 0.81 to 0.91.[10]

Forefoot angle is determined by measuring the angle formed between the line perpendicular to the bisection of the calcaneal bone and a hypothetical line passing through the metatarsal heads. To ascertain the Forefoot angle, the subject was asked to lie prone, with the leg to be tested in extended position and the other leg in externally rotated position alongwith knee flexed at an approximate angle of 90°. A line was drawn on the extended leg in order to bisect its lower one third portion. Another line was marked at the posterior aspect of heel to bisect the calcaneal bone. With one hand holding the subtalar joint in its neutral position, the opposite hand was used to position the goniometer. While the stationary arm of the goniometer was placed at the line perpendicular to the bisection of the calcaneus, the moveable one was aligned along the plane that was found to bisect the metatarsal heads. The angle between these two lines was noted. The values obtained were used to determine the foot as having Forefoot varus, neutral, or valgus. The Intra class coefficients for reliability of Forefoot angle has been established as 0.97 [11].



Figure 1: Positioning of the patient for bisection of tibia and calcaneus

The Rearfoot angle is referred to the angle that is formed between the bisecting line of the lower one third of the leg and the bisecting line of the calcaneal bone. The subject was made to stand on the foot stepper in the relaxed stance position. Thereafter, the subtalar joint was brought in neutral position via palpation method. Fixed arm of the goniometer was placed along the bisecting line of the lower one third of the leg and the movable one was kept in line with the line bisecting the calcaneus. The angle between the two marked lines was noted. ICC for reliability for rear foot angle is 0.90 [11].

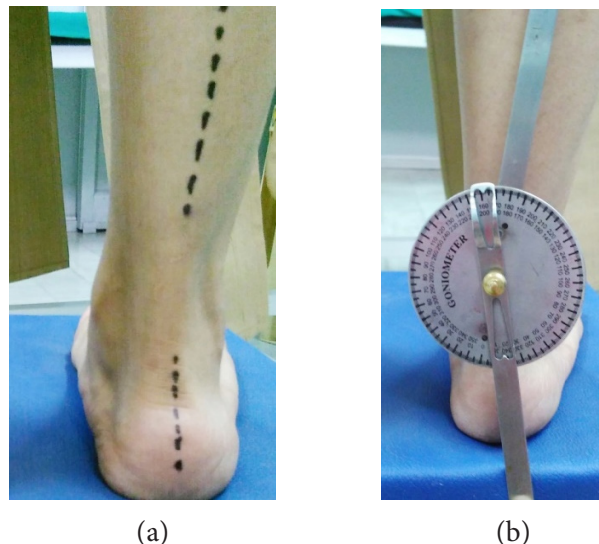


Figure 2: (a) Markings for measurement of Rearfoot angle; (b) Placement of Goniometer for measurement of Rearfoot angle

Navicular Drop was determined by noting down the difference in the navicular height during the subtalar joint neutral position and the relaxed stance position of the foot. The navicular bone of each foot was located by using the standard method of palpation for the navicular bone. The most prominent aspect of the bone was marked with a marker. The subject was then made to stand in bilateral stance on the floor. An index card was kept besides the medial side of the foot. Navicular height was determined by making a mark on the card at the level of the navicular bone. Then the subject was asked to lift the opposite foot and the navicular height was marked on the index card for the foot to be tested. Same procedure was repeated for the opposite side. The difference was noted in the units of millimeter.[11] Intra rater reliability of navicular drop is 0.94-0.98 [12].



Figure 3: Marking of navicular bone on an index card
Medial Longitudinal Arch Angle is the angle formed be-

tween the line joining the midpoint of the medial malleolus to the navicular tuberosity and the another line connecting the midpoint of the first metatarsal head to the navicular tuberosity.[13] For this measurement, subject was made to stand in relaxed bilateral stance position[12] Prominences of the Medial Malleolus and the Navicular bone and the midpoint of the first metatarsal head were marked by a marker. The obtuse angle formed between the lines joining these marks was noted

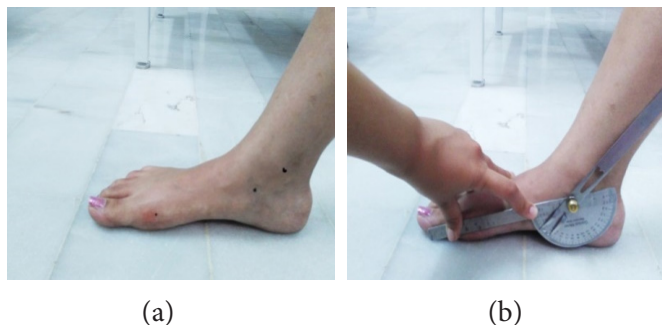


Figure 4: (a) Markings for measurement of Medial Longitudinal Arch angle; (b) Placement of Goniometer for measurement of Medial Longitudinal Arch angle

RESULT

The data was analyzed using Microsoft Office Excel 2010. Mean and Standard deviations were analyzed for Demographic Details. Percentile and Coefficient of Correlation analysis was done to analyse the results. The criteria for statistical significance was fixed at $p \leq 0.05$.

	Highly Pronated	Pronated	Normal	Supi-nated	Highly Supi-nated	Total
Left Foot	24(60%)	13(32.5%)	3 (7.5%)	0	0	40 (100%)
Right Foot	16(40%)	19(47.5%)	5(12.5%)	0	0	40 (100%)

Table 1: Foot postural deviation among Kathak Dancers (N=40) (Foot Posture Index)

Table 1 The observations suggested that 92.5% of the kathak dancers showed Foot Postural Deviations towards pronation in the left foot and 87.5% pronation in the right foot where Highly pronated feet was observed in 60 % (lt) 40% (rt) and pronated feet was observed in 32.5% (lt) and 47.5% (rt) of Kathak dancers. However, rest of the Kathak dancers showed normal feet. None of the kathak dancers showed any deviation towards supination. Thus, results suggest that kathak dancers tend to have Foot Postural Deviations towards pronation.

Table 2: Deviations in Rear foot Angle amongst Kathak Dancers

	Increased	Normal	Decreased	Total
Left Foot	36 (90%)	4 (10%)	0	40 (100%)
Right Foot	24 (65%)	16 (35%)	0	40 (100%)

Table 2 The observations suggested that 90% of the Kathak dancers demonstrated increase in Rearfoot angle at left side and 65% at right side. None of the kathak dancers showed

decrease in rearfoot angle.

Table 3: Deviations in Forefoot Angle amongst Kathak dancers

	Increased	Normal	Decreased	Total
Left Foot	29 (72.5%)	11 (27.5%)	0	40 (100%)
Right Foot	30 (75%)	10 (25%)	0	40 (100%)

Table 3 results suggested that 72.5 % of the Kathak dancers showed increase in forefoot angle at left side and 75% at right side. However, none of them showed decrease in Forefoot angle.

Table 4: Deviations in Medial Longitudinal Arch Angle amongst Kathak dancers

	Decreased	Normal	Increased	Total
Left Foot	38 (95%)	2 (5%)	0	40 (100%)
Right Foot	37 (92.5%)	3 (7.5%)	0	40 (100%)

Table 4 The findings suggested that 95 % of the Kathak dancers showed decrease in Medial Longitudinal Arch angle at left side and 92.5% at right side. However, none of them showed increase in Medial Longitudinal Arch angle.

Table 5: Deviations in Navicular Drop among kathak dancers

	Increased	Normal	Decreased	Total
Left Foot	37 (92.5%)	3 (7.5%)	0	40 (100%)
Right Foot	35 (87.5%)	5(12.5%)	0	40 (100%)

Table 5 observations suggested that 92.5 % of Kathak dancers were found to have increase in Navicular Drop at left side and 87.5% at right side. None of them showed decrease in Navicular Drop.

Coefficient of Correlation analysis was done to determine the relationship of the Foot Postural Deviations with the biomechanical angles at foot.

Table 6: Correlation of FPI scores with other Postural Deviations

	r value	p value
Rearfoot	0.40	0.0087
Medial Arch	-0.42	0.0059*
Forefoot	0.51	0.0007*
Navicular Drop	0.62	< 0.0001*

* $p \leq 0.05$

Table 6 shows correlation of FPI scores with other Postural deviations. The observed values of r for Rearfoot angle ($r = 0.40$), Navicular Drop ($r = 0.62$), Medial Longitudinal Arch angle ($r = -0.42$) and Forefoot angle ($r = 0.51$) suggest a significant correlation. Thus, with changes in foot posture i.e. pronation, Rearfoot angle, Navicular Drop and Forefoot angle tends to increase. However, Medial Longitudinal Arch angle tends to decrease. Thus, there occurs flattening at foot.

DISCUSSION

Kathak dancers have to exhibit footwork throughout their performance. It forms a very essential component of their performance and helps in showing the various kinds of emotions throughout the dance. It is the only medium to give rhythms to the dance along with ghungroos. Any difficulty in performing these foot movements can drastically affect the performance of a Kathak dancer. These difficulties can be attributed to the musculoskeletal changes in their foot which occurs due to their dynamic foot postures during the performance.

The present study was conducted with an aim to find out the various Foot Postural deviations amongst Kathak Dancers. The study also analysed the relationship between them.

Postural deviations in the kathak dancers were assessed using Foot Posture Index. Foot Posture Index calibrates the extent to which a foot can be acknowledged as supinated, pronated or neutral. It helps to assess the posture of the foot in the weight bearing position according to a predefined criterion. Among the kathak dancers in the current study 92.5% presented with postural deviations towards pronation in the left foot and 87.5% presented pronation in the right foot. However none of the dancers demonstrated any deviation towards supination.

Foot Postural deviations toward pronation in Kathak dancers could be related to the basic mudra of these dancers in which they stand erect with the feet placed together. In the beginning of the performance and in between different steps, the dancers have to stand with both their feet facing away from each other and pointing outwards thus forming the walls of an isosceles triangle and the heels of both the feet nearly touching each other thus forming the tip of an isosceles triangle.[15] These positions put the foot into a pronated position. With repetition the foot slowly attains a deviation towards pronation and gets stable or fixed into a pronated position. With passage of time the dancers develop a habit and tend to maintain this abducted position of foot even outside the dance studio during various daily activities such as standing, walking, etc. thus directing the posture of the foot during both static and dynamic weight bearing towards pronation[15].

The present study also analysed various angles in the ankle and foot of the kathak dancers in an attempt to find the other mechanical changes and relate it with the observed deviations at the foot and ankle. These included Rearfoot angle, Forefoot angle, Medial Longitudinal arch angle and Navicular Drop. The Rearfoot angle, Forefoot angle and Navicular Drop were found to be increased and Medial Longitudinal Arch Angle was found to be decreased in majority of Kathak dancers. The Rearfoot angle was increased in 90% (lt) and 62.5% (rt), Forefoot angle was increased in 72.5% (lt) and 75% (rt), Navicular Drop was increased in 92.5% (lt) and 97.5% (rt) and Medial Longitudinal arch angle was decreased in 95% (lt) and 92.5%(rt) of the kathak dancers.

Repetitive tapping on the floor during the kathak dance performance could be related to the observed decrease in the medial Longitudinal Arch and flattening of the foot. Repetitive tapping and overuse of intrinsic muscles weakens the medial arch thus leading the flattening and deviation of the foot towards pronated position. Analysis of Coefficient of Correlation suggested a statistically significant negative relationship between the Medial Longitudinal Arch angle and foot pronation ($r = -0.42, p = 0.0059$).

The Medial Longitudinal arch casts down slightly during weight bearing and rebounds immediately after weight has been removed.[6] This helps in increasing the surface area of the foot contacting the ground via pronation and thus, provides more stability to the foot. This position is maintained throughout contact and mid-stance and immediately as the push off begins the foot goes into supination [15]. But with repetitive tapping and overuse of intrinsic muscles the Medial Longitudinal arch flattens and leads to changes towards pronation. Another factor that could contribute to the flattening of foot is practicing over hard floors. It leads to overuse of invertors of the foot due to the strong contractions required by them on hard floors in order to have a controlled motion at the foot [16].

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 [17].

Further analysis of coefficient of correlation suggested a statistically significant positive relationship of Forefoot angle ($r = 0.40, p = 0.0087$), Navicular Drop ($r = 0.62, p < 0.0001$) and Rearfoot angle ($r = 0.51, p = 0.0007$) with the foot pronation among the participants in the current study.

These findings are supported by a study done by Buchanan *et al.* in 2016 on healthy individuals which suggests a significant relationship betweenof the forefoot angle with relaxed rearfoot angle ($r = 0.52, p = 0.001$) and navicular drop ($r = 0.55, p = 0.001$), thus concluding that changes in the alignment of one tarsal bone brings out changes in bony alignment of other tarsal bones also [11].

The talus lies at a paramount position in the medial arch and thus bears whole of the weight of the body [6]. Depression of medial arch leads to disturbance in alignment of talus. The subtalar joint axis falls below 45° in the sagittal plane thus bringing out excessive pronation at foot along with greater eversion and adduction at rear foot [18] This may disturb the other tarsal bones as well further leading to excessive foot pronation.

Further, Foot Postural Deviations were found to have a statistically significant relationship with the Foot and Ankle injuries in these dancers. Thus, it can be stated that increase in the deviations at foot towards pronation in Kathak dancers may be a cause for high rate of ankle injuries in them. Repetitive foot postures of Kathak dancers during their performance may result in overuse of foot invertors,

plantar flexors and dorsi flexors of foot. Additionally, these motions are performed on hard surfaces. More forceful contraction is needed from the foot muscles due to which with time these muscles get hypertrophied to meet the increased demands and hence cause an exertional compartment syndrome. With exertion, the muscles get fatigued due to which all the stress gets transferred to the bones which could lead to strain at the site of origin of muscles onto the bone giving rise to conditions such as periosteitis, tendonitis, etc. Excessive foot pronation is accompanied with varus at the forefoot which lets the great toe hit the ground thus causing overuse of the extensor hallucis longus muscle [16]. Excessive blister formation which was till now considered to occur only due to friction taking place between the skin and ghunghroos can also be owed to the hyperpronation found in these dancers..

CONCLUSION

From the observations the study concludes that the feet of the kathak dancers are constantly exposed to the forces that can lead to the instability and postural deviations thus the dancers are susceptible to develop many types of foot problems and injuries. Therefore, the study recommends that the dancers should be educated and trained about the foot problems associated with kathak dance and their prevention. A treatment approach should be formulated and tested specifically for the Kathak dancers according to their profession and lifestyle.

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