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# Effect of Active - Resisted Exercise and Stretching on Pronated Foot Posture in Female Indian Classical Kathak Dancer

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## ABSTRACT

***Background:*** Kathak, a classical Indian dance form, involves intricate footwork and expressive movements that often result in a pronated foot posture among female dancers. This study investigates the effectiveness of exercise interventions in correcting pronated foot posture in Kathak dancers.

***Methods:*** Sixty female Kathak dancers were divided into two groups: one group participated in both exercise and dance, while the other group engaged in dance only. Foot posture, arch index, and range of motion were evaluated using the Foot Posture Index (FPI), Arch Index (AI), and universal goniometer measurements before and after a 6-week intervention period. Statistical analysis was performed using SPSS.

***Results:*** In Group A, significant improvements were observed in FPI scores for both right ($p<0.05$) and left feet ($p<0.05$), as well as in Arch Index right: ($p<0.05$); left: ($p<0.05$), Range of motion in foot inversion significantly increased in both feet following the exercise program (right: $p < 0.05$; left: $p < 0.05$). Group B showed no significant changes in FPI, Arch Index, or range of motion (all $p>0.05$).

***Conclusion:*** Active resisted and stretching exercises effectively improved foot posture, arch angle, and range of motion among Kathak dancers, highlighting the importance of targeted exercise interventions in addressing pronated foot issues associated with dance-specific biomechanical demands.

***Keywords:*** Kathak, classical dance, pronated foot, exercise intervention, foot posture.

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## INTRODUCTION

Kathak is recognized as one of the eight primary styles of classical Indian dance [1]. The roots of this art form can be traced back to the wandering minstrels of ancient northern India, known as Kathakars or "storytellers," who conveyed narratives from Hindu epics and mythology through a blend of dance, song, and music. The title Kathak originates from the Sanskrit term "katha," meaning "story," and "kathakar," signifying "the storyteller" or "associated with stories."

Kathak dancers narrate diverse stories through intricate hand movements, elaborate footwork, body flexibility, and expressive facial gestures [2,3]. It incorporates classical elements such as nritta (pure dance), nritya (expressive dance), and natya (dramatic performance). This spirited dance form involves the use of dance bells (ghungroos) to maintain equilibrium within the body during rotational movements (chakkars) and to provide beat to the execution. Dancers utilize facial gestures (abhinaya) to convey emotions and employ their arms and feet to create expressive poses known as mudras [4]. Kathak exists in four distinct forms, known as "gharana", named after the cities where the Kathak dance tradition originated – Jaipur, Benares, and Lucknow – each gharana emphasizes different aspects: Jaipur on intricate foot movements, and Benares and Lucknow on expressive facial gestures and graceful hand movements [5]. There are numerous variations observed across various Kathak dance forms due to its tradition of being transmitted through the guru-shishya parampara. Additionally, slight modifications occur as learners adjust postures to suit their individual body inclinations. However, specific foundational movements typically remain unchanged [6]. The Kathak dance form highlights foot movements rhythmically, which is enhanced by ghungroos, synchronized harmoniously with the music [7,8]. Kathak dancers perform without footwear, yet the ankle bells they wear produce a pronounced clattering sound, accentuated by their technique of vigorous stamping and precise rhythmic shifts [9]. The existence of ghungroos increases the strain sensed in the lower extremity. The whole set of bells comprises approximately 150 ghungroos, totaling around one and a half kilograms of load on the ankle.

During Kathak dance performances, dancers must execute rapid swirling movements with precision. These swirls, often referred to as pirouettes, culminate in the formation of intricate mudras [10]. In a performance, the count of these swift pirouettes can vary from one to 108, typically organized in multiples of three [11]. The foot of a Kathak dancer experiences ongoing stress during their daily routines, leading to adaptations in its mechanics to compensate for these forces [12]. A dancer's good biomechanics are essential to withstand unusual weight-bearing pressure. Dancers often experience increased joint and bone loading forces on their bodies. The majority of these dysfunctions manifest during the dancer's turn or jump landing. Dancers must land on one foot for a lot of their jumps. This frequently puts the dancer at a disadvantage and increases the risk of injury [13, 14].

Approximately 92.5% of Kathak dancers demonstrate a disposition characterized by dorsiflexion, eversion, and abduction in their left foot, with 87.5% exhibiting similar deviations in their right foot. Studies suggest that the medial longitudinal arch angle is diminished in 95% of dancers on their left side and 92.5% on their right side [15].

Traditional Indian classical dance requires extensive use of the lower extremities, exposing dancers to significant impact forces that can alter foot arches and contribute to overuse injuries, frequently leading to pronated feet. Kathak, a distinctive style of Indian classical dance, emphasizes sharp rhythmic shifts and vigorous foot stamping, which can tighten muscles in the lower extremities and heighten injury risks. This study aims to investigate the effects of both active-resisted exercises and stretching on pronated foot posture among female practitioners of the Indian classical dance form, Kathak.

## METHOD

### Study design

The study employed a comparative analysis to evaluate interventions targeting pronated foot posture among 60 female Kathak dancers in Bengaluru, aged 18 to 30 years, each with at least 4 years of Kathak experience and participating in weekly sessions lasting 5 to 6 hours [16].

Participants were selected through purposive sampling based on their active involvement in Kathak and the presence of a pronated foot posture attributed to dance movements. Exclusion criteria encompassed prior use of plantar supports, congenital foot deformities, recent lower limb, spine, or abdominal trauma, surgery [16], also subjects with ankle instabilities [17] and with any neurological dysfunction, musculoskeletal dysfunction, and psychiatric conditions [18]. The study spanned eight months, during which thorough data collection and analysis tracked changes in foot posture to evaluate the effectiveness of interventions in improving foot mechanics and reducing injury risk.

### Procedure

The study utilized a 180-degree universal goniometer to evaluate range of motion, a brush, ink, and white A4 paper to measure arch angle, and the Foot Posture Index to assess foot alignment. Institutional ethical approval was obtained from the Ethics Committee before commencing the study. Participants were well-informed about the study's objectives and procedures, and each provided written consent prior to participation. They were selected based on specific criteria. For the initial assessment of foot conditions, the study employed the Foot Posture Index (FPI) [19], Arch Index (AI) [20, 21], and a universal goniometer (UG) [22]. Participants performed various activities, including treading on the back and front, inside and outside edges of the foot, lifting tiny particles with their toes, engaging in resistance exercises such as inversion and eversion using elastic bands, hip abduction exercises, and strengthening exercises for the erector spinae, abdomen, and obliques. Additionally, they performed leg exercises, balance exercises on unstable surfaces, calf stretches, and plantar fascia stretches [23]. The exercise program was

conducted over six weeks, with sessions held four times per week. Each session lasted 45 minutes and included various exercises performed for 8 to 12 repetitions per set. Depending on the participant's capacity and response, 2 to 3 sets were completed for each exercise. To help manage fatigue and support recovery, a one-minute rest period was incorporated between sets. Following the treatment period, reassessment of foot conditions was conducted using the FPI, AI, and UG.

**Outcome measure**

To determine the Foot Posture Index (FPI) scores, which range from -12 to +12 to assess foot posture deviation, participants were instructed to stand with relaxed limbs, double-limb support, arms by their sides, and eyes directed forward. Following positioning and instructions, all six FPI components were evaluated based on predefined criteria. Evaluation of the rear foot included palpating the talus head, noting curves around the lateral malleoli, and assessing calcaneus inversion/eversion. The examination of the forefoot included observing the bulge at the joint between the talus and navicular bone, assessing the congruity in the medial longitudinal arch, and observing forefoot movement inside and outside about the hindfoot. Positive scores indicated pronated postures, with higher values suggesting greater pronation, while negative scores indicated supinated postures. A neutral foot typically resulted in an FPI score near zero.

The Arch Index was used to quantify the area proportion occupied by the middle 1/3rd of the foot to the total area, excluding the toes. Participants had their foot soles painted with ink (Figure 1) and were instructed to stand on white A4 paper, bearing full weight, to capture footprints for both feet (Figure 2). An axis was drawn from the midpoint of the heel to the top of the second toe on each print, with perpendicular lines marking the front and back edges, without toes. Subsequently, the foot axis was divided into three equal sections to calculate the Arch Index. This was done by dividing the area of the middle section (representing the arch) by the total footprint area. In this method, A corresponds to the forefoot region, B to the midfoot (arch) region, C to the rearfoot (heel) region, and L represents the total length of the footprint (Fig:3). Foot classification was based on the Arch Index results: a value between 0.21 and 0.28 indicated a normal foot, values greater than 0. 28 suggested pronation, and values less than 0. 21 suggested supination.

**Figure 1: Painting the foot.**

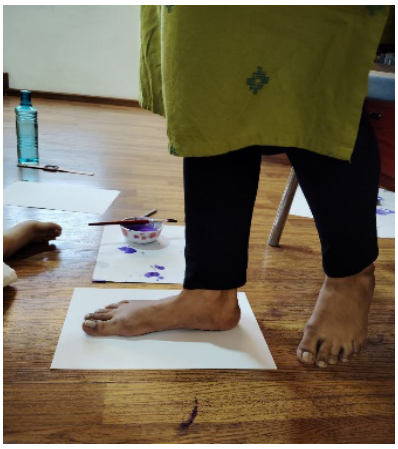

**Figure 2: Standing on one leg with full weight bearing.**

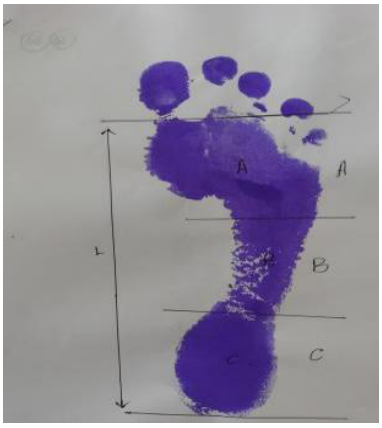


**Figure 3: Segmentation of the foot into three equal parts (A, B, C)**

The procedure for measuring ankle inversion and eversion involved having the patient sit on an examination table with their legs hanging off the edge and their feet in a neutral position. The tibial crest and the second metatarsal bone were palpated to align the goniometer. The fulcrum was placed above the anterior ankle joint, equidistant between the lateral and medial malleolus. The stationary arm was positioned with the tibia midline extending towards the tibial tuberosity, while the mobile arm was positioned with the second metatarsal midline.

The patient was instructed to invert and evert their foot as far as they could comfortably. The normal range for ankle inversion was 0 to 35 degrees, and for ankle eversion was 0 to 15 degrees. In pronated foot posture, a reduction in inversion range and an augmentation in eversion range were noted.

## RESULT

The data were analyzed using SPSS version 20.0, and descriptive statistics were employed to determine the mean and standard deviation for both demographic variables and outcome variables. Paired t–test employed to find out the significant differences within the group among the variables such as Foot Posture, Arch Angle, and Range of Motion. An independent t–test was used to determine significant differences between the groups in variables such as Foot Posture, Arch Angle, and Range of Motion.

**Table 1: Range, mean, and SD of age of the female Kathak dancers in both the groups**

| Variable | Group-A | | Group-B | | | |
|---|---|---|---|---|---|---|
| | Range | Mean ± SD | Range | Mean ± SD | Mann-Whitney U | Sig. (2-tailed) |
| Age in years | 18-30 | 23.93 ± 4.30 | 18-29 | 24.37 ± 3.01 | 427.500 | 0.738 |

Table 1: Presents the outcomes of age in years for the female kathak dancers in both groups. In group A, the subjects ranged in age from 18 to 30, with a mean and SD of 23.93±4.30. In group B, the subjects ranged in age from 18 to 29, with a mean and SD of 24.37±3.01. There is no significant difference between the age groups of participants from A and B ($p>0.05$). Therefore, the null hypothesis is accepted. The alternate hypothesis was rejected.

**Table 2: Independent sample t-test between the groups of A and B**

| GROUP | | Mean | Std. Deviation | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|
| FOOT POSTURE INDEX - RIGHT PRE TEST | GROUP A | 9.5667 | .85836 | .881 | 58 | .382 |
| | GROUP B | 9.3000 | 1.41787 | | | |
| FOOT POSTURE INDEX - LEFT PRE TEST | GROUP A | 9.5667 | 1.07265 | 1.030 | 58 | .307 |
| | GROUP B | 9.2000 | 1.62735 | | | |
| FOOT POSTURE INDEX - RIGHT POST TEST | GROUP A | 7.6333 | .88992 | -12.167 | 58 | .000 |
| | GROUP B | 10.7000 | 1.05536 | | | |
| FOOT POSTURE INDEX - LEFT POST TEST | GROUP A | 7.5667 | .93526 | -9.549 | 58 | .000 |
| | GROUP B | 10.7000 | 1.53466 | | | |
| ARCH INDEX - RIGHT PRE TEST | GROUP A | .3230 | .02087 | -.357 | 58 | .723 |
| | GROUP B | .3250 | .02255 | | | |
| ARCH INDEX - LEFT PRE TEST | GROUP A | .3113 | .02177 | -.192 | 58 | .849 |
| | GROUP B | .3123 | .01851 | | | |
| ARCH INDEX - RIGHT POST TEST | GROUP A | .2510 | .01647 | -18.560 | 58 | .000 |
| | GROUP B | .3350 | .01852 | | | |
| ARCH INDEX - LEFT POST TEST | GROUP A | .2570 | .01985 | -15.961 | 58 | .000 |
| | GROUP B | .3310 | .01583 | | | |
| GONIOMETER INVERSION RIGHT PRE TEST | GROUP A | 16.7333 | 1.59597 | -.086 | 58 | .932 |
| | GROUP B | 16.7667 | 1.40647 | | | |
| GONIOMETER EVERSION RIGHT PRE TEST | GROUP A | 24.4333 | 2.28463 | 1.546 | 58 | .127 |
| | GROUP B | 23.7000 | 1.23596 | | | |
| GONIOMETER INVERSION LEFT PRE TEST | GROUP A | 16.1667 | 1.64177 | -.361 | 58 | .719 |
| | GROUP B | 16.3000 | 1.17884 | | | |
| GONIOMETER EVERSION LEFT PRE TEST | GROUP A | 23.2000 | 1.44795 | .089 | 58 | .929 |
| | GROUP B | 23.1667 | 1.44039 | | | |
| GONIOMETER INVERSION RIGHT POST TEST | GROUP A | 23.7333 | 1.92861 | 18.830 | 58 | .000 |
| | GROUP B | 15.9000 | 1.21343 | | | |
| GONIOMETER EVERSION RIGHT POST TEST | GROUP A | 16.2667 | 1.91065 | -16.538 | 58 | .000 |
| | GROUP B | 23.6000 | 1.49943 | | | |
| GONIOMETER INVERSION LEFT POST TEST | GROUP A | 22.0000 | 2.10090 | 13.293 | 58 | .000 |
| | GROUP B | 16.1333 | 1.19578 | | | |
| GONIOMETER EVERSION LEFT POST TEST | GROUP A | 16.3000 | 2.47957 | -14.412 | 58 | .000 |
| | GROUP B | 23.6333 | 1.27261 | | | |

Foot Posture Index (FPI):

Before the intervention: No significant difference between Group A and Group B for either foot ($p > 0.05$).

Following the intervention, a clear difference was observed between the groups. Group A had lower FPI scores, indicating improved foot posture, while Group B's scores remained higher ($p < 0.05$). → Interpretation: Group A showed noticeable improvement in foot posture.

Arch Index:

Before the intervention: No significant difference between the groups ($p > 0.05$).

Following the intervention, Group A exhibited significantly lower Arch Index values, indicating improved arch structure, whereas Group B's values remained higher ($p < 0.05$). → Interpretation: Group A showed improved arch condition.

Goniometer Measurements (Inversion and Eversion):

Before the intervention, there was no significant difference in ankle movement between the two groups ($p > 0.05$).

Following the intervention, Group A exhibited increased inversion and reduced eversion angles, whereas Group B showed the opposite pattern ($p < 0.05$). → Interpretation: Group A demonstrated better ankle control and mobility.

## DISCUSSION

In Kathak performances, highlighting footwork is crucial as it not only provides rhythmic accompaniment to the dance but also enhances the auditory experience

through the resonant sound of ghungroos. However, any difficulties encountered in executing these intricate foot movements can profoundly affect a Kathak dancer's overall performance. These challenges typically stem from musculoskeletal adjustments in the feet, which are shaped by the dynamic postures maintained throughout their performances.

This study investigated the effects of active resistance exercises and stretching exercises on the pronated foot posture of female Indian classical Kathak dancers, comparing measurements taken before and after the interventions. The study by Sabhrawal et al. (2017) underscores the prevalence of foot and ankle disabilities among Kathak dancers, with a significant portion experiencing ankle instability [17]. This aligns with broader findings in professional dance, where the repetitive and strenuous movement characteristic of dance forms such as Kathak and musical theatre can lead to a high incidence of injuries. The inherent characteristics of a dancer's feet, particularly in Kathak, where extreme plantar flexion is common, contribute to the instability observed in the ankles of these dancers. This instability can result from the repeated stress placed on the ankle joints during performances, causing them to be pushed into unstable positions frequently.

Sabhrawal et al. (2017) also shed light on the biomechanical challenges faced by Kathak dancers due to their unique foot positions and movements. The present study highlights the efficacy of targeted exercises in mitigating the impact of repetitive tapping and intrinsic muscle overuse in Kathak dancers. By comparing pre- and post-outcome measures of arch index (Right – 0.2510 ± 0.01647, Left – 0.2570 ± 0.01985) and foot posture index (Right – 7.6333 ± 0.88992, Left – 7.5667 ± 0.93526), the study highlights that strengthening intrinsic foot muscles can significantly improve foot posture and reduce arch index deviations among female Kathak dancers. This suggests that integrating specific exercises tailored to enhance intrinsic foot muscle strength could serve as a proactive strategy to uphold foot health and stability within the context of Kathak dance. Such interventions not only address immediate concerns related to foot posture deviations but also potentially mitigate long-term risks associated with repetitive dance movements. As dancers strengthen their intrinsic foot muscles, they may experience enhanced stability and resilience, which in turn supports overall performance and reduces the likelihood of injury. The studies conducted by Shefali Naik et al. (2019) provide complementary insights into the musculoskeletal issues faced by Kathak dancers, particularly concerning foot posture and low back pain [23]. Shweta Chandan et al. (2018) study identified a high prevalence of pronated and excessively pronated feet among Kathak dancers, which constituted a significant portion of their sample [13]. The finding suggests that many dancers may exhibit structural foot deviations due to the repetitive nature of Kathak dance movements, potentially exacerbated by intrinsic muscle overuse during performances. In relation to foot posture, the pronated and excessively pronated feet observed in Chandan's study could contribute to altered biomechanics and increased stress on the lower extremities. This aligns with Naik and Ranade's findings on the prevalence of lower back pain among dancers in Pune. The high incidence of low back pain (59%) reported in their study may be linked to altered foot posture. Pronated feet can lead to biomechanical imbalances that affect the entire kinetic chain, potentially placing additional strain on the lower back during dance movements [23].

Individuals with pronated feet often experience reduced ability to invert and increased ability to evert due to altered alignment and muscle function. Pronation causes the foot to flatten, lowering the medial side and collapsing the arch. This alignment shift naturally promotes eversion over inversion, exacerbated by the elongation of the foot's soft tissues. In the current study, significant improvements were observed in inversion (Right: 23.7333±1.92861, Left: 22.0000±2.10090) and eversion (Right: 16.2667±1.91065, Left: 16.3000±2.47957) following active resisted exercises and stretching exercises. These interventions effectively addressed the misalignment and enhanced the foot's range of motion, demonstrating their impact on foot posture and function in individuals with pronated feet.

There was a lack of literature concerning interventions in cases of pronated feet among Kathak dancers. Excessive tapping and repetitive use of the intrinsic muscles can lead to the flattening of the medial longitudinal arch, resulting in a shift in the direction of pronation. Another contributing reason to this flattening can be the habit of practicing on hard surfaces, which necessitates increased contraction of the foot's invertors for controlled movement [24].

The initial study, conducted by Arjun Patel et al. (2022), concentrated on a younger demographic aged 8 to 23 years, involving a smaller sample size of 40 participants [25]. In contrast, the subsequent current study targeted an older age group of 18 to 30 years, comprising a larger cohort of 60 participants. According to the study by Raquel, a 9-week program focusing on intrinsic and extrinsic foot muscles, as well as core muscles, effectively improved hyperpronation in adults with pronated feet [22]. The current study underscores the importance of strengthening intrinsic foot muscles, ankle stabilizers, hip abductors, and core muscles to maintain proper foot alignment and manage excessive pronation [17]. Furthermore, enhancing balance and proprioception through exercises has been shown to improve neuromuscular control, thereby stabilizing foot positioning and preventing overpronation. Additionally, stretching exercises were found to be crucial for enhancing flexibility in tight muscles and connective tissues, such as the calves and plantar fascia, promoting better alignment and reducing pronation tendencies.

## CONCLUSION

This comparative study found that active resistance exercises combined with stretching routines were more effective than no intervention in improving foot posture, arch structure, and ankle mobility among female Kathak dancers. Participants who performed these exercises showed greater improvements in foot alignment, arch support, and range of motion—particularly through

increased inversion and reduced eversion—compared to those in the control group. These results underscore the effectiveness of targeted exercises in managing pronated foot conditions in this population.

**LIMITATIONS**

Only female dancers were taken.

Small sample size estimation done.

No particular gharana has been chosen.

**RECOMMENDATION**

Both genders can be taken.

Sample size can be increased.

Intervention can be given based on specific gharanas, and the effects can be studied.

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