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Original Research Article

Impact of intrinsic foot muscle training on foot posture and foot functional activity among female kathak dancers with flat feet

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ABSTRACT

Background: Kathak being one of the very complex Indian classical dance forms, has a greater emphasis on foot work thus putting substantial amount of stress over foot which leads to weakness of intrinsic foot muscles, flat foot and functional impairments. Hence current study aimed to study the impact of intrinsic foot muscle strengthening on foot posture and functional activity among female kathak dancers with flat feet.
Methods: In this Quasi-Experimental Study, 30 females kathak dancers with flat feet between the age group of 18-40 were selected according the inclusion and exclusion criteria from different Kathak dance academies in Pimpri and Pune. All participants were given intrinsic foot muscle strengthening (5 exercises) for 2 times a week for 4 weeks which were progressed after 2 weeks. Pre and post treatment assessments were done for foot deviations and foot functional activity by Foot posture index and foot function index respectively.
Results: Paired T test for pre and post treatment analysis was done with statistical. significant at $P<0.05$ and 95% confidence interval. FFI score was reduced post treatment with mean difference of 1.26 which was statistically insignificant ($p>0.05$) but clinically significant. There was no statistically as well as clinically significant difference between the pre and post treatment FPI scores of both right and left leg ($p>0.05$).
Conclusions: Intrinsic foot muscle training showed clinically significant improvement in foot function index but did not show any improvement in foot posture.

Keywords: Flat feet, Foot function index, Foot posture index, Kathak dancers, Intrinsic foot muscles

INTRODUCTION

The traditional Indian classical dance form of Kathak is renowned for its captivating storytelling and vibrant imagery. It encompasses various elements such as nritta (pure dance), nritya (expressive dance), and natya. Kathak demands vigorous physical and mental engagement, with dancers executing intricate footwork, expressive gestures (mudras), and spinning movements (chakkars) at different speeds (laya) to create rhythm in their performance.[1]

An essential aspect of Kathak to enhance the complex foot work is the use of ghungroos, ankle bells weighing between 1 to 1.5 kg. This intensifies the demands on the legs, as they have to work harder to lift the feet, which causes the agonists - antagonists muscle imbalance at a faster rate. Overloading of lower limb leads to potential injuries like foot pain and tendon strains. Kathak dancers practice V stance which is an extremely turned-out foot stance, leading to functional hyperpronated foot.[2]

Excessively low medial longitudinal arched foot, known as flat feet has been linked to abnormal tibialis posterior tendon sheath functions, including pain, damage to the joint, dynamic imbalance, and even stress fractures.[3] The biomechanical interactions among the anatomical structures of the foot and their functions are known to be intricate. The proper functioning of the foot relies greatly on the integrity of the medial longitudinal arch (MLA), as it is crucial for transferring forces throughout the foot. Additionally, the intrinsic muscles are essential as they contribute significantly to foot strength. Comprising four layers including the abductors halluces, flexor digitorum brevis, abductor digiti minimi, and quadratus plantae, these muscles work together to support the foot arch. Preserving the foot arch is vital as it aids in distributing weight evenly during weight-bearing activities.[4]

The extensive utilization of intrinsic foot muscles is a significant aspect of the foot movements in Kathak dancers, involving repetitive and forceful tapping on hard surfaces, which heavily relies on strong contractions of these muscles. This repetitive strain can lead to muscular weakening, resulting in the flattening of the foot arch and diminished overall performance among dancers. 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.[5]

Kathak dancers are particularly susceptible to foot ailments and deviations in foot posture, leading to recurrent injuries and arch flattening. Research by Shweta Chandan et al in 2018 examined foot posture in Kathak dancers, concluding that they exhibit a higher prevalence of pronated and excessively pronated foot postures.[6] Such flattening of the arch contributes to postural instability and balance issues, particularly problematic for dancers who frequently engage in twists, turns, and jumps.

Furthermore, a foot injury can cascade into ankle injuries and beyond along the kinetic chain, affecting a dancer's functionality, especially during landing after jumps or turns.[7] These challenges extend beyond the dance studio, impacting dancers' daily lives as they adopt poor postures outside of dance class.[1]

In Kathak, there is a significant focus on footwork, resulting in considerable stress on the feet due to prolonged practice. This stress often leads to a range of issues including foot postural deviations, heel pain, tenderness, and trigger points in the foot, which in turn can lead to postural instability impacting their daily activities.[1] The weakening of intrinsic foot muscles not only affects the quality of performance but also contributes to postural deviations and impaired foot function. These effects can be assessed through tools like the foot posture index and the foot functional index, which evaluate foot posture and functional activity respectively.[8]

The foot posture index (FPI) was utilized as a diagnostic clinical tool aimed at quantifying the degree to which a foot can be considered to be in a pronated, supinated or neutral position.[9] Additionally, the Foot Functional Index (FFI) was employed as a self-report instrument to measure pain and disability related to foot function. Developed in 1991, the FFI evaluates multiple dimensions of foot function and is widely accepted by clinicians and researchers. This self- administered index consists of 23 items, categorized into three sub-scales, providing scores for both the entire scale and each sub-scale individually.[7]

The existing literature highlights several cross-sectional studies that have examined the morphology, postural deviations, and functional aspects of the feet among classical dancers. However, there is a notable lack of research focusing on the rehabilitation and strengthening of intrinsic foot muscles (IFM). Therefore, the current study aimed to investigate the effects of IFM strengthening on foot posture and foot functional activity among female Kathak dancers with flat feet.

METHODS

After obtaining ethical approval from the Institutional Ethics Committee, a Quasi-experimental study was conducted at physiotherapy OPD of Dr. D. Y. Patil College of Physiotherapy, Pimpri, Pune, Maharashtra between October 2023 to March 2024. 30 female Kathak dancers with flat feet between the age group of 18-40 were selected according to the inclusion and exclusion criteria by purposive sampling technique from various kathak academies in Pimpri Chinchwad, Pune. The aim and method of the study was explained and informed written consent was taken from all participants.

Inclusion criteria

Females kathak dancers with flat feet, age group of 18-40 years, duration 2 or more than 2 years of dancing, 5-6 hours of dance practice per week, normal BMI- 18.5-24.9 Kg/m^2, subjects willing to participate in the study were included.

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 were excluded.[3]

Following IFM strengthening exercises were given to all participants for 2 times a week for 4 weeks. They performed 1 set of 10 repetitions for each exercise for first 2 weeks and they were progressed to 2 sets for each exercise for next 2 weeks. Rest interval of 1 min was given between each set and of 2 mins between each exercise.

1)	 Short Foot Exercise	**Short foot exercises:** This exercise was performed by shortening and raising the medical longitudinal arch by bringing the metatarsal heads towards the calcaneus without flexing the toes or contracting the extrinsic foot muscles.
2)	 Towel Curls	**Towel curls:** A towel placed on the floor and the subject was instructed to stand on it and to crumple the towel with the help of the foot.
3)	 Toes Spread Out Exercise	**Toes – Spread- Out Exercise** – this was performed by extending all 5 toes and then simultaneously abducting all 5 toes while also flexing the first and fifth toes to the ground, keeping toes 2 to 4 extended. The middle toes were then relaxed.
4)	 First Toe Extension Exercise	**First - Toe Extension Exercise** – was performed by extending the great toe while the second to fifth toes remained on the floor in a neutral position.
5)	 Second to Fifth Toe Extension Exercise	**Second – to Fifth – Toe – Extension Exercise** – This was performed by extending the second to fifth toes while the great toe remained flat on the floor.

Figure 1: Intrinsic foot muscle strengthening exercises.

Pre and post treatment assessment was done for foot deviations and foot functional activity by Foot posture index and foot function index respectively for all the participants.

Foot posture index

FPI was used as a screening tool to assess foot posture and participants who had flat feet were included in the study. Then it was also used as an outcome measure to assess impact of IFM strengthening on foot posture. In this index the rear foot was evaluated by palpating the head of the talus, examining the curves above and below the lateral malleoli, and determining how much the calcaneus is inverted or everted. The fore foot was observed by measuring the talonavicular joint bulge, the medial longitudinal arch's congruence, and the degree of forefoot abduction and adduction relative to the rear foot. Participant was asked to remain still and variations in the foot's angles were measured to get the foot posture index. After calculating each score on the six-component foot posture index scale, the results were: (0) for neutral, (+2) for pronated, and (-2) for supinated. The final score ranged from -12 to +12 and was a whole number.10

Foot function index

This self-reported index with good validity and reliability was used to assess foot functional activity. It consists of 23 items divided into 3 subscales that quantify the impact of foot pathology on pain, disability, and activity limitation in patients. Participant was asked to score 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. Scoring was done for each sub scale separately and then total score of entire scale was calculated.[7]

Statistical analysis

The data was analysed for both descriptive and inferential analysis using the statistical package for social sciences (SPSS) software version 23. Mean and standard deviations were analysed for age, BMI and quantitative measurements. Pre and post treatment analysis for FPI and FFI scores was done by paired T test with statistically significant at $P<0.05$ and 95% confidence interval.

RESULTS

The study population included 30 female kathak dancers. The mean and SD of age of study population were 25.55±8.32 and for BMI was 22.65±2.25.

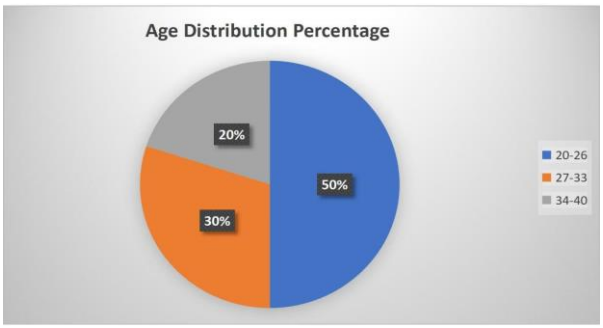

Figure 2: Age distribution of study population.

Figure 2 represents age distribution among study population which showed that maximum participants that is 50% were from age group 20-26 years and minimum participants that is 20% were from age group 34-40 years.

Table 1 represents pre and post treatment comparison of foot posture and foot function. Results showed that post treatment mean FFI score was reduced from 10.46 to 9.2. For FFI, the t-statistic value was 1.09 with a p-value of 0.28, which was greater than the typical significance level of 0.05. Therefore, we failed to reject the null hypothesis. This suggests that treatment may not have had a statistically significant effect on FFI but it may have clinically significant improvement in foot function as FFI score was reduced post treatment with mean difference of 1.26.

Results revealed that there was no change in the mean of FPI for right and left foot post treatment. The t-statistic value was -0.72 with a p-value of 0.48 for right limb and -0.7 with p value 0.43 for left limb, which is greater than the typical significance level of 0.05. Therefore, we failed to reject the null hypothesis. This suggests that there is no statistically as well as clinically significant difference between the pre and post treatment FPI scores indicating that the treatment may not have had a significant effect on foot posture.

Table 1: Pre and post treatment comparisons of quantitative measurements.

Quantitative measurements	Mean±SD		Mean difference	P value	T value
	Pre	Post			
FFI	10.46±2.33	9.2±2.1	1.26	1.09	0.28
FPI (right)	8.31±1.64	8.29±1.64	0.02	-0.72	0.48
FPI (left)	8.1±2.48	8.1±2.48	0	-0.7	0.43

DISCUSSION

The objective of the study was to evaluate the effect of intrinsic foot muscle strengthening on foot posture and foot function in female kathak dancers with flat feet. The study was conducted on 30 females kathak dancers with flat feet between the age group of 18-40 years.

FPI calibrated the extent to which a foot can be acknowledged as supinated, pronated or neutral. FFI assessed foot functional activity by quantifying pain, disability and activity limitation. 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.[11] Results showed that there was no statistically as well as clinically significant difference between the pre and post treatment FPI scores of both right and left leg ($p>0.05$) indicating that the treatment may not have had a significant effect on foot posture.

Foot postural deviations toward pronation in Kathak dancers could be related to the basic mudra (V stance) of these dancers in which they stand erect with the feet placed into a pronated position. With passage of time and repetition of movements 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. One more contributing factor to pronated foot is excessive use and weakening of IFM as they play a vital role in preserving the arch of the foot.[1]

IFM training helps to gain strength of these muscles and better functioning. Lynn et al studied about the differences in static and dynamic-balance task performance after 4 weeks of intrinsic foot muscle training by comparing the short foot exercise versus the towel curl exercise. They investigated the effects of 2 different types of IFM training on the height of the MLA and static and dynamic balance task performance. Study concluded that short foot exercises appeared to train the IFM more effectively than the Towel curl exercise.[12]

Current study provided IFM training for 4 weeks which turned out to be insufficient to observe foot posture correction because reversing the biomechanical changes and foot postural correction will happen over longer period of time. Also, other factors affecting flattening of arch such as use of appropriate foot wear, long duration of dance practice were not considered and analysed in the current study. Hence lack of positive effect of treatment on foot posture can be explained by requirement of longer duration of treatment (more than 4 weeks) and follow up to reflect on structural change. Our study findings are in accordance with Pabón-Carrasco et al who studied the effect of exercise of the intrinsic muscle on foot pronation and concluded that statistically significant values were not found in foot posture between the experimental and the control groups when comparing before and after intrinsic foot muscle training.[13] Namsawang et al investigated the effects of the Short foot exercise alone and after adding neuromuscular electrical stimulation in healthy people diagnosed with flexible flat feet. They concluded that there was no significant difference found in navicular height after SFE.[14]

Walls et al stated in his study that overuse injuries of the foot and ankle have been frequently reported in athletes and professional dancers and leads to pronated foot.[15] Kathak dancers are exposed to enormous stresses at foot which can likely affect their performance and function of the foot. Further analysis revealed that there was minimal improvement in foot function as FFI score was reduced post treatment with mean difference of 1.26 which was statistically insignificant ($p>0.05$) but clinically significant.

Our study population showed less score with mean 1.46 as they did have no or minimal disability and activity limitation. This minimal impairment of foot function was mainly present due to foot pain. Post treatment score of FFI further reduced to 0.20 as there was reduction in foot pain caused due to strengthening of IFMs. Improvement in function could be because of strengthening IFM stabilizing foot during functional activities, supporting foot arches. Enhanced recruitment of IFM played role in improving quality of movement and injury prevention which did not lead to any pain, activity limitation or

dysfunction. Thus, the present study showed minimal improvement in foot function index. Andhare et al also supported benefits of IMF training in 2018, by stating that Intrinsic muscle training for foot musculature improves balance in Bharatnatyam dancers.[4] Current study findings are supported by Fraser et al who stated that 4-week IFM exercise intervention resulted in improved motor performance and decreased perceived difficulty when performing the exercises.[16]

Limitation of current study encompasses inclusion of female population only with small sample size and short duration protocol. Future studies can include long duration treatment with follow ups to assess better improvement in foot posture and foot function. Also, evaluation of IFM strength, use of appropriate footwear and involvement of extrinsic foot muscle strengthening can be considered for future scope of research.

CONCLUSION

IFM training showed clinically significant improvement in foot functional activity but did not show any improvement in foot posture with strengthening protocol of 4 weeks. IFM training should be incorporated in routine exercise for long duration for kathak dancers for injury prevention and rehabilitation.

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