

Effect of Foot Intrinsic and Tibialis Posterior Muscle Training on Dynamic Balance in Bharatanatyam Dancers a Comparative Study

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Abstract

Background: Dancers require good body balance to maintain and continuously change the postures. Due to repetitive foot tapping, changes are seen in the medial longitudinal arch causing flat foot in Bharatanatyam dancers which affects their balance and overall performance while dancing. Strengthening extrinsic and intrinsic muscles is more effective interventions for flexible flat foot. Although foot muscle exercises for the height of MLA have been limited to intrinsic foot muscle strengthening without considering extrinsic foot muscle. Exercise interventions that comparing foot intrinsic muscle and extrinsic muscle are rare and studies of dynamic balance in relation to the pes planus in Bharatanatyam dancers are lacking. Therefore, the present study includes a comparison of the effects of foot intrinsic and tibialis posterior muscle training, in relation with foot arch height, dynamic balance, and performance in Bharatanatyam dancers with flexible flat foot.

Objective: To compare the effects of foot intrinsic muscle and tibialis posterior muscle training on dynamic balance in Bharatanatyam dancers.

Method: 30 flexible pes planus Bharatanatyam dancers were recruited and were randomized into two groups. Group A performed foot intrinsic muscle training and group B performed tibialis posterior muscle training. All groups received strength training for 30 minutes five times a week for six weeks

Results & Discussion: Statistical analysis was done using paired t test for intragroup significance and independent t test for intergroup significance. Results obtained revealed that both groups showed significant difference between their pre-test and post-test values ($p \geq 0.05$).

However intergroup analysis showed no significant difference ($p \leq 0.05$) between group A (Foot intrinsic muscle training) and group B (Tibialis posterior muscle training) in SEBT, FPI 6 and DFOS.

Conclusion: Tibialis posterior muscle strengthening group is equally effective as foot intrinsic muscle strengthening in terms of foot posture, dynamic balance and Dance function.

Keywords: "Bharatanatyam dancers"; "Tibialis posterior"; "Dynamic balance".

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Introduction

Bharatanatyam is an Indian classical dance form which involves continuously changing postures, to attain which dancers need optimum muscle strength, RoM and dynamic balance.¹

Balance is also a necessary component of daily living activities and sports.² Dynamic balance is the ability to maintain stability of CoM during movements. The process of maintaining balance is complex and involves co-ordination of sensory, motor and biomechanical components.¹

The feet of Bharatanatyam dancers are constantly exposed to high impact forces and the incidence of flat foot is 75%. Foot arch Flattening causes postural instability and balance problems in healthy population, which reduces overall performance in dancers.³⁻⁵

Among the conservative treatments, foot muscle exercises can reduce excessive pronation, improve foot muscle strength, functions and restructure the foot and being simple to perform.⁶

Foot muscles are subdivided into intrinsic and extrinsic muscles. Intrinsic foot muscles comprise four layers of small muscles, which include Abductors hallucis, Flexor digitorum brevis, Abductor digiti minimi, and Quadratus plantae. It primarily stabilizes the arch and assist standing postures, dynamic balance and support the MLA during push-off in the stance phase.^{7,8} Toe curls and short foot exercises are most commonly recommended for intrinsic muscle strengthening.⁹⁻¹²

Extrinsic foot muscles especially Tibialis posterior muscle which maintains foot supination for the longest time, maintains MLA during dynamic weight bearing and balance. Provides foot adduction, supination, plantar flexion and assists in controlled flattening of MLA through eccentric contractions during stance phase of gait cycle.⁷ Foot adduction and supination being most effective for selective strengthening of tibialis posterior muscle.¹³

Foot muscle exercise interventions for flatfoot treatment have been limited to intrinsic foot muscle strengthening without considering extrinsic foot muscles.¹⁴ Traditional practices of dancers need

to be carefully studied and juxtaposed with the modern system of physical training to provide scientific recommendations to prevent injuries and offer right treatment. The present study examines the effects of strengthening tibialis posterior muscle, as well as intrinsic foot muscles related to foot arch height, dynamic balance and dance functions in Bharatanatyam dancers.¹⁵

Methodology

Study settings: Chithambaram Kalaakshethram, Iritty, Kannur, Kerala, India

Sample size: 30

Inclusion criteria

- Both male and female subjects.
- 15 to 20 years of age
- > 3 years of Bharatanatyam training, formal training for ≥ 6 months, and currently practicing for ≥ 6 hours a week.
- FPI 6 score $\geq +6$

Study procedure

30 Bharatanatyam students (group A-15 subjects, group B-15 subjects) fulfilling the inclusion criteria were included in study. Informed consent was obtained and pre-evaluation of foot posture, dynamic balance and dance functions have done using FPI-6, SEBT and DFOS respectively. A brief demonstration about the procedure was given. Both groups received strength training for 30 minutes, five times a week, for six weeks.

Group A: Intrinsic Muscle Strengthening Exercises

1. Short Foot Exercise

Sit with good posture in sturdy chair, with feet on the floor, toes facing straight forward and the knees 90° bend. Inhale and contract the muscles on bottom of the foot and lower legs, to raise the foot arch without curling toes. Hold for 6 seconds.

2. Towel Curl Exercises

Place towel under foot, flat. Sit with heels under the knees. Feet parallel to each other with toes pointing forward. Heels should stay in place on towel. Pull the towel towards the heel.

Group B: Tibialis Posterior Muscle Strengthening Exercises

1. Foot Adduction Resistance Exercise

Sit with feet on floor, forearm length apart and knees bent to 80°. For leg stability, place forearms on opposite sides of leg. providing Elastic bands depending on subject's muscle strength, which were wound around medial and lateral sides of foot, tied up, and pulled laterally at an angle of 45° to the floor. Feet should be flat, in contact with the floor, and move as they sweeping the floor.

2. Foot Supination Resistance Exercise

Place one leg on and stand at the lateral end of footboard with knee joint of limb which placed on the footboard maintaining a bend. Subject placed medial part of heel and foot at the base of 3rd metatarsal bone on the edge of footboard to perform foot supination.

FINDINGS

SEBT

- **Anterior**

In group A, mean difference of pre and post-test mean scores of left feet was 1.87. Paired 't' test value of $t=4.525$ found to be statistically significant at $p<0.001$. Mean difference in right foot was 2.60 and paired 't' test value of $t=6.703$ found to be statistically significant at $p<0.001$.

In group B, mean difference of pre and post-test mean score in left foot was 2.06. Paired 't' test value of $t=6.546$ was statistically significant at $p<0.001$. Mean difference in right foot was 1.73 and paired 't' test value of $t=3.591$ found to be statistically significant at $p<0.01$.

Independent 't' test values was not statistically significant at $p < 0.05$ level. There is an equal and significant improvement in dynamic balance (left and right foot- anterior) in both groups

- **Postero-medial**

In group A, mean difference of pre and post-test mean score in left foot was 1.93. Paired 't' test value of $t=6.808$ found to be statistically significant at $p<0.001$. Mean difference score of pre and post-test mean score in right foot was 2.13. Calculated paired 't' test

value of $t=5.870$ found to be statistically significant at $p<0.001$.

In group B, mean difference of pre and post-test mean score in left foot was 2.53. Paired 't' test value of $t=8.264$ was statistically significant at $p<0.001$. Mean difference score of pre and post-test mean score in right foot was 2.0. Paired 't' test value of $t=7.746$ was found to be statistically significant at $p<0.001$.

Independent 't' test values was not found to be statistically significant at $p < 0.05$ level. This clearly infers that there is an equal and significant improvement in dynamic balance (left and right foot-postero medial) in both groups

- **Postero-lateral**

In group A, mean difference of pre and post-test mean score in left foot was 2.40. Paired 't' test value of $t=9.431$ was found to be statistically significant at $p<0.001$. Mean difference in right foot was 2.13. Paired 't' test value of $t=6.346$ was found to be statistically significant at $p<0.001$

In group B, mean difference of pre and post-test mean score in left foot was 2.20. Calculated paired 't' test value of $t=6.454$ was statistically significant at $p<0.001$. mean difference in right foot was 1.80. The calculated paired 't' test value of $t=5.511$ was found to be statistically significant at $p<0.001$.

Independent 't' test values were not found to be statistically significant at $p < 0.05$ level. This clearly infers that there is an equal and significant improvement in dynamic balance (left and right foot-postero lateral) in both groups.

FPI 6

In group A, mean difference of pre and post-test mean score in FPI 6 was 1.13. Paired 't' test value of $t=8.500$ was statistically significant at $p<0.001$.

In group B, mean difference of pre and post-test mean score in FPI 6 was 0.93. Paired 't' test value of $t=6.089$ was statistically significant at $p<0.001$.

Independent 't' test values was not statistically significant at $p < 0.05$ level. This clearly infers that there is an equal and significant improvement in foot posture in both groups.

DFOS

In group A, mean difference of pre and post-test mean score in DFOS was 0.87. Paired 't' test value of $t=2.827$ was statistically significant at $p<0.05$.

In group B, mean difference of pre and post-test mean score in DFOS was 1.20. Paired 't' test value of $t=4.294$ was statistically significant at $p\leq 0.001$.

Independent 't' test values was not statistically significant at $p < 0.05$ level. Clearly infers that there is equal and significant improvement in foot posture of both groups.

Discussion

The feet of Bharatanatyam dancers are constantly exposed to high impact forces and are more susceptible to postural deviations, instability and injuries which reduces overall performance in dancers. Previous studies recommend that the dancers should be well trained about foot problems and their prevention. Bharatanatyam dancers should be formulated a treatment-based program according to their lifestyle and profession.

Flexible flatfoot can be due to muscular dysfunction, bone malformation, ligament loosening or Achilles tendon shortening. Tibialis posterior tendon and spring ligament are stretched in FFD, decreasing the functional ability of dynamic and static stabilizers and reduces the height of MLA.⁹ Intrinsic and extrinsic musculature can support the MLA and increase the arch height with proper strengthening protocols.¹⁷

Recent studies suggested that to correct foot pronation inducing MLA flattening, increasing the strength of intrinsic and extrinsic muscles is the most effective method.¹⁸ Currently, studies that comparing effect of intrinsic foot muscle training and tibialis posterior muscle training in relation to the dynamic balance of Bharatanatyam dancers are lacking. The purpose of this study was to investigate and compare the effect of intrinsic and extrinsic foot muscles strengthening and how this would affect dynamic balance and dance functions in Bharatanatyam dancers.

30 Bharatanatyam dancers fulfilling inclusion criteria were included in the study. Most of them have

started Bharatanatyam practice at a very young age between 4-7 years but, the full maturation of foot arch takes place at the age of 5-6 years. Therefore, excessive strain like loading on the foot with continuous foot tapping over the hard surface produces high level compressive force over the heel, tarsal and metatarsal joints, which may alter the integrity of foot arch structure thus leading to flat foot.⁴

They were allocated to two groups- groups A and B, each containing 15 subjects. Intrinsic muscle strengthening exercises were given to group A and tibialis posterior muscle strengthening exercises given to group B. Both groups received training for 30 minutes, five times a week, for six weeks. Outcomes were measured: foot posture by FPI-6, dynamic balance by SEBT and dance functions by DFOS.

Difference in average mean age, height and weight of the subjects in both groups were negligible.

Y balance test which was developed by Plisky to overcome limitations of traditional SEBT, with good interrater reliability was used to measure dynamic balance.¹⁹

FPI 6 determines foot posture based on 6 individual criteria, with excellent intra-rater reliability.²⁰

DFOS is self-report questionnaire for healthy and injured dancers, focusing on low back and lower extremities to provide detailed information about dancer's quality and capacity to perform complex tasks.²¹

In group A, mean difference of pre and post-test mean scores of SEBT (anterior) on left foot was 1.87. Paired 't' test value of $t=4.525$ was statistically significant at $p<0.001$. Mean difference in right foot was 2.60 and paired 't' test value of $t=6.703$ was statistically significant at $p<0.001$.

In group B, mean difference of pre and post-test mean scores of SEBT (anterior) in left foot was 2.06. Paired 't' test value of $t=6.546$ was statistically significant at $p<0.001$. Mean difference in right foot was 1.73 and paired 't' test value of $t=3.591$ was statistically significant at $p<0.01$.

Independent 't' test values was not statistically significant at $p < 0.05$ level. This clearly infers that there is an equal and significant improvement in SEBT (anterior) of both groups

In group A, mean difference of pre and post-test mean score of SEBT (Postero-medial) in left foot was 1.93. Paired 't' test value of $t=6.808$ was statistically significant at $p < 0.001$. Mean difference score of pre and post-test mean score in right foot was 2.13. Paired 't' test value of $t=5.870$ was statistically significant at $p < 0.001$.

In group B, mean difference of pre and post-test mean score of SEBT (Postero-medial) in left foot was 2.53. Paired 't' test value of $t=8.264$ was statistically significant at $p < 0.001$. Mean difference score of pre and post-test mean score in right foot was 2.0. Paired 't' test value of $t=7.746$ was statistically significant at $p < 0.001$.

Independent 't' test values were not statistically significant at $p < 0.05$ level. Clearly infers that there is an equal and significant improvement in SEBT (postero medial) of both groups.

In group A, mean difference of pre and post-test mean score of SEBT (Postero-lateral) in left foot was 2.40. Paired 't' test value of $t=9.431$ was statistically significant at $p < 0.001$. Mean difference in right foot was 2.13. Paired 't' test value of $t=6.346$ was statistically significant at $p < 0.001$

In group B, mean difference of pre and post-test mean score of SEBT (Postero-lateral) in left foot was 2.20. Paired 't' test value of $t=6.454$ was statistically significant at $p < 0.001$. Mean difference in right foot was 1.80. Paired 't' test value of $t=5.511$ was statistically significant at $p < 0.001$.

Independent 't' test values were not statistically significant at $p < 0.05$ level. This clearly infers that there is an equal and significant improvement in SEBT (postero lateral) in both groups.

In group A, mean difference of pre and post-test mean score in FPI 6 was 1.13. Paired 't' test value of $t=8.500$ was statistically significant at $p < 0.001$.

In group B, mean difference of pre and post-test mean score in FPI 6 was 0.93. Paired 't' test value of $t=6.089$ was statistically significant at $p < 0.001$.

Independent 't' test values were not statistically significant at $p < 0.05$ level. This clearly infers that there is an equal and significant improvement in foot posture in both groups.

In group A, mean difference of pre and post-test mean score in DFOS was 0.87. Paired 't' test value of $t=2.827$ was statistically significant at $p < 0.05$.

In group B, mean difference of pre and post-test mean score in DFOS was 1.20. Paired 't' test value of $t=4.294$ was statistically significant at $p \leq 0.001$.

Independent 't' test values were not statistically significant at $p < 0.05$ level. This clearly infers that there is an equal and significant improvement in foot posture in both groups.

Result from the statistical analysis of this study supports the null hypothesis which stated that there is no significant difference between the effects of Foot intrinsic muscle training and Tibialis posterior muscle training on dynamic balance in Bharatanatyam dancers. The participants were equally benefited from both intrinsic muscle training and tibialis posterior muscle training in terms of foot posture, dynamic balance and dance performance in Bharatanatyam dancers.

Conclusion

Both the Foot intrinsic muscle training and Tibialis posterior muscle training can significantly improve foot posture, dynamic balance and dance performance in Bharatanatyam dancers and the difference between the changes produced by both the interventions are negligible.

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