

Biomechanical Assessment of Q-Angle and Foot Alignment in Bharatanatyam Dancers

Nirmiti Prasad Ahiwale¹, Dr. Mahendra Shende²

¹Intern Indutai Tilak College of Physiotherapy, Tilak Maharashtra Vidyapeeth, Pune.

²Principal and Professor Indutai Tilak College Of Physiotherapy, Tilak Maharashtra Vidyapeeth, Pune.

Abstract

Background: Bharatanatyam involves repetitive footwork, stamping, turnout and sustained deep knee-flexed postures such as araimandi. These demands may influence lower-limb alignment. The present study assessed Q-angle and foot alignment in Bharatanatyam dancers using the Q-angle, Foot Posture Index-6 (FPI-6), and Navicular Drop Test (NDT).

Methods: An observational study using convenience sampling was conducted among 75 female Bharatanatyam dancers aged 18–23 years who had at least three years of training and were currently practicing or performing. Q-angle was measured bilaterally in standing and supine positions using a goniometer. Static foot posture was assessed with the FPI-6 and medial longitudinal arch change with the NDT. Descriptive statistics were used to summarize the measurements.

Results: The reported sample mean age was 20.32 ± 1.69 years, with mean Bharatanatyam training of 10.59 ± 3.32 years and mean practice of 12.24 ± 2.83 hours/week. Mean standing Q-angle was $20.85 \pm 3.23^\circ$ on the right and $21.12 \pm 3.64^\circ$ on the left; mean supine Q-angle was $19.67 \pm 2.78^\circ$ and $19.33 \pm 3.04^\circ$, respectively. Pronated foot posture was reported in 49 participants on each side, while 41/75 (54.7%) were reported to have pronated posture on at least one side. Mean NDT was 1.93 ± 2.10 on the right and 1.90 ± 2.06 on the left, and 40/75 (53.3%) were reported to have excessive NDT according to the study cutoff.

Conclusion: The study identified frequent variations in knee and foot alignment among the sampled Bharatanatyam dancers. The findings support the use of multidimensional lower-limb screening in this population.

Keywords: Bharatanatyam; Q-angle; Foot Posture Index; Navicular Drop; foot alignment; dance biomechanics; physiotherapy

1. Introduction

Bharatanatyam is a demanding Indian classical dance form characterized by complex postures, intricate footwork, repetitive movements, stamping, rapid weight shifts and sustained turnout. The dance requires prolonged performance in deep knee-flexed positions, particularly araimandi or demi-plié, which place substantial mechanical demands on the lower limbs. Repeated loading and limited recovery may contribute to changes in lower-limb biomechanics and may be relevant to musculoskeletal symptoms and injury.

The Q-angle is the angle formed by the line of pull of the quadriceps mechanism and the patellar tendon. It is commonly used clinically to describe alignment of the extensor mechanism of the knee. The project

report used an approximate female reference range of 15–18°. Alterations in knee alignment may be relevant to patellofemoral mechanics and the distribution of forces around the lower limb.

Foot alignment is also important because the foot forms the distal foundation of the lower-limb kinetic chain. Altered foot posture may influence the alignment and loading of the ankle, knee and proximal segments. Bharatanatyam is commonly performed barefoot and involves forceful foot strikes and sustained postures, making foot assessment clinically relevant.

Previous work cited in the project has described musculoskeletal injuries, altered foot characteristics, postural changes and lower-limb kinematic or kinetic demands in Bharatanatyam dancers. A study by Zawar et al. reported relationships between Q-angle and selected foot variables in professional Bharatanatyam dancers, while other cited studies have highlighted lower-extremity injury patterns and differences in foot characteristics between dancers and non-dancers.

The project identified a need to consider knee and foot alignment together in Bharatanatyam dancers. Therefore, the present study assessed Q-angle in standing and supine positions, static foot posture using FPI-6, and medial longitudinal arch change using the NDT.

2. Aim and Objectives

Aim: To assess the biomechanical characteristics of the lower limbs, specifically Q-angle and foot alignment, in Bharatanatyam dancers.

- To measure Q-angle with a goniometer in standing and supine positions.
- To assess foot alignment using the Foot Posture Index-6 (FPI-6).
- To assess medial longitudinal arch change using the Navicular Drop Test.

3. Materials and Methods

3.1 Study design and setting

This was an observational study conducted among Bharatanatyam dancers attending classes in and around Pune, Maharashtra, India. Convenience sampling was used. The final study sample comprised 75 dancers.

3.2 Participants

The inclusion criteria were female dancers aged 18–23 years, with at least three years of Bharatanatyam training, who were currently practicing or performing. Participants with lower-limb musculoskeletal injury or recent lower-limb surgery, neurological deficits, congenital deformities, or recent injury were excluded.

3.3 Outcome measures

Q-angle was measured using a goniometer. The three anatomical landmarks were the anterior superior iliac spine, centre of the patella and tibial tuberosity. The FPI-6 was used to classify static foot posture as highly supinated, supinated, neutral, pronated or highly pronated. The NDT was used to quantify the change in navicular height between non-weight-bearing and relaxed weight-bearing conditions.

3.4 Procedure

Institutional Ethical Committee permission was obtained from Tilak Maharashtra Vidyapeeth, Pune. Written informed consent was obtained from participants and the study procedure was explained before assessment. Demographic information was recorded. Q-angle was measured bilaterally first in standing and then in supine. FPI-6 assessment was performed in relaxed standing using its six clinical criteria. For NDT, navicular height was measured in a non-weight-bearing condition and repeated during relaxed full weight bearing; navicular drop was calculated as the initial height minus the final height.

3.5 Statistical analysis

Data were reported using descriptive statistics including mean, standard deviation, median and range for continuous variables and frequencies and percentages for categorical FPI-6 classifications. The project protocol states that normality was to be examined using the Shapiro–Wilk test and that Pearson or Spearman correlation would be selected according to distribution, with statistical significance set at $p < 0.05$.

4. Results

The final project report analyzed 75 participants. The reported mean age was 20.32 ± 1.69 years. Mean height, weight and BMI were 163.20 ± 4.81 cm, 57.45 ± 5.53 kg and 21.62 ± 1.43 kg/m², respectively. Mean Bharatanatyam training duration was 10.59 ± 3.32 years and mean practice time was 12.24 ± 2.83 hours/week.

Variable	Mean $\pm$ SD	Median	Range
Age (years)	20.32 ± 1.69	20.0	18–23
Height (cm)	163.20 ± 4.81	162.0	155–172
Weight (kg)	57.45 ± 5.53	57.0	48.9–68.8
BMI (kg/m ²)	21.62 ± 1.43	21.4	19.2–24.0
Training (years)	10.59 ± 3.32	11.0	5–19
Practice (hours/week)	12.24 ± 2.83	12.0	8–20

Table 2. Q-angle measurements

Q-angle measurement	Mean $\pm$ SD (°)	Median (°)	Range (°)
Standing – Right	20.85 ± 3.23	22.0	14–25
Standing – Left	21.12 ± 3.64	22.0	14–25
Supine – Right	19.67 ± 2.78	20.0	13–23
Supine – Left	19.33 ± 3.04	20.0	13–23

Table 3. FPI-6 category distribution

FPI-6 category	Right n (%)	Left n (%)
Highly Supinated	0 (0.0%)	0 (0.0%)
Supinated	1 (1.3%)	0 (0.0%)
Neutral	16 (21.3%)	15 (20.0%)
Pronated	49 (65.3%)	49 (65.3%)
Highly Pronated	9 (12.0%)	11 (14.7%)

Table 4. Navicular Drop

Measurement	Mean $\pm$ SD	Median	Range
Right	1.93 ± 2.10	1.40	0.60–11.00
Left	1.90 ± 2.06	1.30	0.80–10.00

The report further states that 41 of 75 participants (54.7%) had a pronated foot posture on at least one side and that 40 of 75 (53.3%) demonstrated excessive Navicular Drop according to the cutoff used in the study. The report also states that 86.7% of participants demonstrated at least one of the specified biomechanical alterations.

5. Discussion

The present study examined knee and foot alignment in 75 Bharatanatyam dancers. The participants represented a trained group, with a reported mean of more than ten years of Bharatanatyam training and approximately twelve hours of practice per week. The findings indicate that variations in Q-angle, static foot posture and navicular mobility were present within the study population.

The reported Q-angle values provide a description of knee extensor-mechanism alignment in both standing and supine conditions. Bharatanatyam involves repeated knee flexion, squatting, turnout and forceful footwork. These movement demands may expose the lower limb to repeated mechanical loading. The project literature review also cites previous work describing altered lower-limb kinematics and substantial knee loading during Bharatanatyam movements.

Foot posture findings showed that pronated posture was common in the reported dataset. FPI-6 identified 49 right and 49 left feet as pronated, while a total of 41 participants were reported to have pronation on at least one side. These findings are consistent with the broader rationale of the study that repetitive stamping, turnout, araimandi and other dance-specific positions may be associated with changes in foot mechanics. The NDT findings also indicated variation in medial longitudinal arch mobility. The project report states that 40 participants (53.3%) demonstrated excessive NDT on at least one side according to the study cutoff. Previous literature cited in the project has described differences in foot characteristics between Bharatanatyam dancers and age-matched non-dancers, supporting the relevance of objective foot assessment in this population.

The relationship between foot and knee biomechanics is likely multifactorial. Individual anatomical characteristics, muscle strength, flexibility, dance technique and training exposure may all contribute to observed alignment patterns. Because the present study was cross-sectional and primarily assessed static measures, the findings should be interpreted as a description of biomechanical characteristics rather than evidence that Bharatanatyam training caused the observed changes.

6. Clinical Implications

The findings support consideration of routine lower-limb screening in Bharatanatyam dancers. Assessment of Q-angle together with static foot posture and medial longitudinal arch mobility may provide a broader picture than assessment of a single alignment parameter. Where clinically indicated, physiotherapy management may include individualized strengthening, flexibility, balance, intrinsic foot-muscle training, postural correction and technique modification.

7. Limitations

- The cross-sectional design does not establish a cause-and-effect relationship between dance training and biomechanical characteristics.
- The participants were young female dancers aged 18–23 years, limiting generalizability to other age groups and populations.

- The study primarily assessed static biomechanical parameters and did not analyze dynamic dance movements.
- Dance style, detailed posture and technique, footwear, injury history, muscle strength and flexibility were not comprehensively examined.
- Advanced biomechanical methods such as three-dimensional motion analysis, force plates, plantar-pressure analysis and radiographic assessment were not used.

8. Conclusion

Among the 75 Bharatanatyam dancers evaluated in the project, variations in Q-angle and foot alignment were reported. Pronated foot posture on at least one side was reported in 54.7% of participants, excessive Navicular Drop in 53.3%, and at least one specified biomechanical alteration in 86.7%. These findings emphasize the potential value of multidimensional lower-limb screening in Bharatanatyam dancers and provide a basis for further research using larger samples and dynamic biomechanical assessment.

9. Ethics and Consent

Institutional Ethical Committee permission was obtained from Tilak Maharashtra Vidyapeeth, Pune, according to the project report. Written informed consent was obtained from participants. The source report states that participant information was intended to be kept confidential and anonymized for analysis and publication.

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