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Postural analysis in female Bharatanatyam dancers: a cross-sectional study

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Abstract

Background: Gaining proficiency in Bharatanatyam dance form necessitates maintenance of different postures for prolonged duration. These repetitive movements place tremendous physical demands on the body at young age and may alter the postural profile of the dancer. The study aimed to evaluate the differences in terms of posture between female Bharatanatyam dancers and age-matched non-dancers. A cross-sectional study was conducted in 40 female Bharatanatyam dancers and 40 age-matched female non-dancers in the age group of 18 to 30 years. Analysis of erect standing posture of dancers and non-dancers was conducted in a reserved environment using a photogrammetric method. Static photographs of the subjects were taken in the sagittal plane. The measurement of the angles of the digitized photographs was performed using KINOVEA 0.8.15 software. Head protrusion angle, cervical lordosis angle, thoracic kyphosis angle, lumbar lordosis angle, and pelvic tilt angle were evaluated.

Results: There was no significant difference between the dancers and non-dancers with respect to head protrusion angle ($p = 0.081$), cervical lordosis ($p = 0.15$), and thoracic kyphosis ($p = 0.33$). Significant differences were identified between the dancers and non-dancers for lumbar lordosis ($p = 0.00$) and pelvic tilt ($p = 0.00$) using independent t test with dancers. Higher values of lumbar lordosis and pelvic tilt were observed in dancers.

Conclusion: Increased lumbar lordosis and anterior pelvic tilt were observed in Bharatanatyam dancers as compared to non-dancers. Hence, it is vital to establish preventive measures like postural re-education, muscular balance, and flexibility to prevent erroneous postural patterns capable of causing pain and injuries.

Keywords: Bharatanatyam, Dancer, Photogrammetric, Posture

Background

Bharatanatyam, an ancient dance form, is known for its graceful, expressive, and sculpturesque poses which demands high levels of physical and psychological power during performance. It necessitates continuous delicate changes with incorporation of one leg positional holds (for poses), swift body turns (single-legged or double), quick movement transitions, specific rigorous footwork, changes in positions and stances, and maintenance of postures [1]. A Bharatanatyam curriculum comprises of initial 5 to 7 years of training required to be qualified for a graduation. The training is provided and supervised by the dance teacher, qualified personnel. Bharatanatyam is a mixture of combination of three elements—*Nritta*, *Nritya*, and *Natya*. *Nritta* highlights body movements and rhythm. *Nritya* gives emphasis to dance postures and body movements. *Natya* gives importance to drama and poem [2]. The foundation of this dance form consists of basic steps along with rhythmic stamping of the feet and a multitude of crisp and meaningful gestures. It incorporates maintenance of a particular position for prolonged period of time accompanied with footwork and coordinated upper limb movements. Gaining proficiency in Bharatanatyam requires rigorous training for prolonged periods of time while maintaining specific postures which begin at a very young age during the adolescent growth spurt [3].

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Body posture refers to the position of a person's body in space, the alignment of body parts in relationship to one another and to the environment at one point in time, and is influenced by each of the body's joints [4]. Another definition of posture, it is a state of muscular and skeletal balance which protects the supporting structures of the body against the injury, irrespective of the attitude in which these structures are working or resting [5]. In physiological and biomechanical terms, a good posture provides the maximum competence control with minimum effort [6]. To maintain a good posture, alignment of the corporal segments is a must to minimize muscular torque and tension throughout the whole kinetic chain. Posture is one of the vital components of Bharatanatyam dance form which comprises three basic positions namely "Araimandi" (half-sitting position), "Muzhumandi" (full sitting position), and "standing" [7, 8].

A cross-sectional observational study conducted in 19 classical ballerinas in Brazil evaluated posture using the photogrammetric method with help of Posturograma® and SAPO© software. It revealed that ballet leads to changes in body alignment. The postural profile of the classical ballerinas showed inclination and protrusion of the head, trunk rotation, rectification of cervical lordosis, increased thoracic kyphosis, increased lumbar lordosis, pelvic inclination, and anteversion [9]. There is a similarity between the Araimandi position adopted by a Bharatanatyam dancer with demi plie in and ballet [10]. However, there is no literature revealing about postural changes in Bharatanatyam dancer.

Dancer is often considered as an athlete due to the tremendous physical demands placed on the body. They constantly strive to perfect the subtle and aesthetic details in their performance [7]. At young age, muscle strength, range of motion, and flexibility are still in developmental phase. Intensive training during this phase may cause physical and biomechanical changes leading to permanent structural alteration. These may be the intrinsic risk factors perpetuating musculoskeletal injuries in dancers [11, 12]. A recently published study revealed that the point prevalence of pain in female Bharatanatyam dancers is high (75%) with low back being the commonest site of pain [3].

Practice of a faulty posture for a long time in one's dancing career could also result in a permanent structural change leading to overuse injuries [6, 13]. There is a huge lacuna in the area of dance medicine particularly in relation to postural changes in Bharatanatyam dancers. Hence, the primary aim of the study was to evaluate the differences in terms of posture between female Bharatanatyam dancers and age-matched female non-dancers.

Methods
Study design
This study was a cross-sectional study design, utilizing exploratory analysis. The study was approved by institutional research review committee. The study was conducted for three months from June to September 2019. The data was collected at MGM College of Physiotherapy, Navi Mumbai, India.

Sample size calculation
To our knowledge, there have been no previous results on the comparison of postural angles between Bharatanatyam dancers and non-dancers. Using open epi software version 3, considering confidence interval 95%, power 80%, a total of 34 participants per group were required for the study. We rounded it off to 40 participants in each group.

Participant recruitment
The target population was 40 female Bharatanatyam dancers and 40 age-matched female non-dancers. The inclusion criteria were female Bharatanatyam dancers in the age group 18–30 years, within the normal body mass index range (18.5 to 24.9 kg/m^2) with a minimum of five consecutive years of formal dance training from dance institutes and academies. Exclusion criteria for both Bharatanatyam dancers and age-matched non-dancers were any history of neuromusculoskeletal pathology; injury to spine, upper and lower extremity; presence of any congenital deformity; history of any spine or extremity surgery; scoliosis and past history of pregnancy. In addition to this for age-matched non-dancers, subjects having any current or past training in any dance form or sport were excluded. All participants were explained about the purpose of study and written informed consent was obtained from each participant.

Data collection
Demographic data of the participants—age in years, and height in centimeter, weight in kilograms and body mass index in kilogram/meter^2 was noted. The dancing characteristics of Bharatanatyam dancers—minimum age when dance training began (years) and total duration of dance experience (years) was recorded.

Posture assessment
Analysis of erect standing posture of dancers and non-dancers was conducted in a reserved environment using a photogrammetric method, a reliable and valid method [14–16]. It was carried out by a qualified and experienced physiotherapist with a postgraduate qualification. The distance between the digital camera (13 megapixels Omni vision technologies by One Plus) and the subject

was 2.4 m and the camera held 1.0 m above the ground. The room was well lit and privacy was maintained.

The preparatory procedures for acquiring images, marking the anatomical points, and tracing the referential lines for the computerized measurement were performed by following the method described in the literature for studying postural profile of ballet dancers [9].

Anatomical points were marked out, including the tragus of the ear, occipital protuberance, C4, C7, T7, T12, L3, and L5 spinous processes, greater trochanter, anterosuperior iliac spine (ASIS), and posterosuperior iliac spine (PSIS) using markers [9].

Static photographs of the subjects were taken in the sagittal plane (Fig. 1).

The measurement of the angles of the digitized photographs was performed using KINOVEA 0.8.15 software [17, 18].

The intersection of line between the tragus and C7 spinous process and the line parallel to the ground forms the head protrusion angle. The smaller the angle
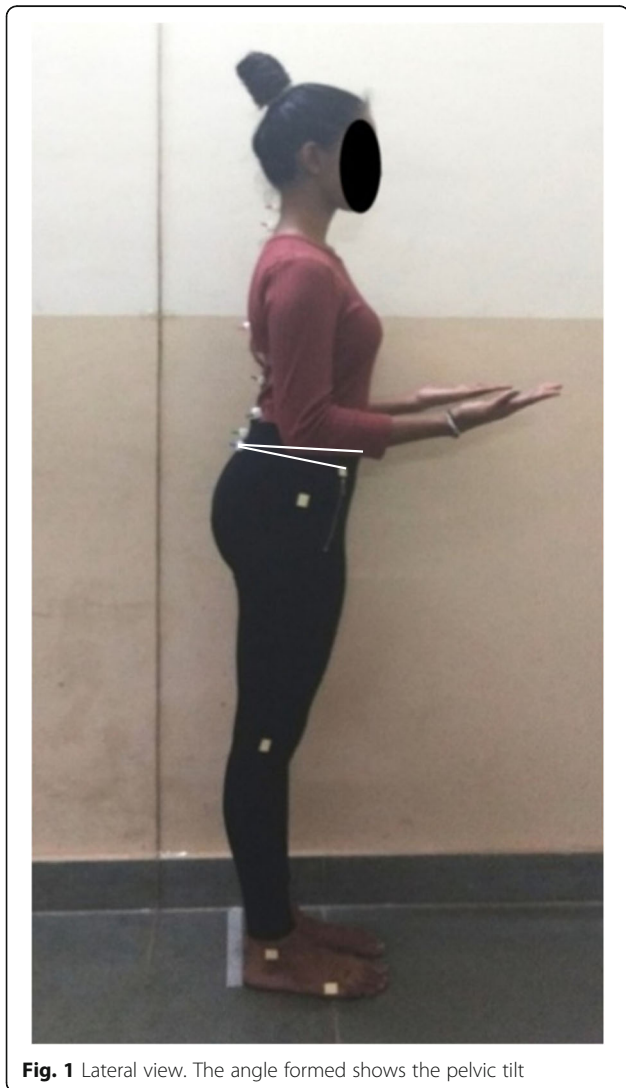
Fig. 1 Lateral view. The angle formed shows the pelvic tilt

is, the greater the protrusion. Cervical lordosis angle is formed by the intersection of the line between occipital protuberance and the horizontal extension of C4 spinous process and the line between C7 spinous process and the horizontal extension C4 spinous process. The smaller the angle, the greater the lordosis. The thoracic kyphosis angle is formed by intersection of the line between C7 spinous process and horizontal extension of T7 spinous process and the line between T12 spinous process and the horizontal extension of T7 spinous process on the plumb line. The smaller the angle, the greater the kyphosis. The lumbar lordosis angle is formed by intersection of the line between T12 spinous process and horizontal extension of L3 spinous process on and the line between L5 spinous process and horizontal extension of L3 spinous process on the plumb line. The smaller the angle, the greater the lordosis. The pelvic tilt angle is formed by the intersection of the line between PSIS and ASIS and the line parallel to the ground. The larger the angle, greater the anterior tilt [19].

Statistical analysis
Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS version 24) (IBM Corporation, NY, USA). Descriptive statistics were used to describe baseline characteristics of all participants using mean values and standard deviation (SD) for continuous variables or frequency and proportions for categorical variables. The normality of the data was assessed using Shapiro-Wilk test. The data was normally distributed. The differences in terms of postural angles between female Bharatanatyam dancers and age-matched non-dancers were analyzed using independent t test. A 5% level of probability was considered as statistically significant.

Results
Demographic characteristics
Table 1 presents demographic and dance training characteristics of the participants. The mean age of dancers and non-dancers was 21.33 ± 3.1 and 21.6 ± 2.75 years, respectively. The average total duration of dance experience for dancers was 14.2 ± 3.8 years. The average minimum age when the dancers began formal training was 6.5 ± 2.3 years.

Postural angles
There was no significant difference between the dancers and non-dancers with respect to head protrusion angle ($p = 0.081$), cervical lordosis ($p = 0.15$), and thoracic kyphosis ($p = 0.33$). Significant differences were identified between the dancers and non-dancers for lumbar lordosis ($p = 0.00$) and pelvic tilt ($p = 0.00$) using independent

Table 1 Demographic characteristics of Bharatanatyam dancers and non-dancers

Characteristics	Dancers Mean ± SD	Non-dancers Mean ± SD
Age (in years)	21.4 ± 3.12	21.6 ± 2.75
Height (in cm)	160.11 ± 5.21	160.87 ± 4.41
Weight (in kg)	58.07 ± 9.08	56.79 ± 7.54
BMI (in kg/m^2)	22.74 ± 3.58	22.06 ± 3.05
Total dancing duration (in years)	14.21 ± 3.84	–
Minimum age when dance training began (in years)	6.53 ± 2.34	–

SD standard deviation, *BMI* body mass index

t test (Table 2). Increased lumbar lordosis and anterior pelvic tilt was observed in Bharatanatyam dancers as compared to non-dancers.

Discussion

The present study aimed to evaluate differences in posture between female Bharatanatyam dancers and age-matched female non-dancers. A significant difference was observed in lumbar lordosis and pelvic tilt between dancers and non-dancers. Increased lumbar lordosis and anterior pelvic tilt was observed in Bharatanatyam dancers. However, head protrusion angle, cervical lordosis and thoracic kyphosis showed no difference. As per our knowledge, this is the first study to analyze the postural profile of Bharatanatyam dancers.

Dance is an art form where perfection results from a delicate balance between artistry and physical skill. In Bharatanatyam dance form, Araimandi position is commonly incorporated posture where the dancer must maintain an upright and erect trunk position with the abdomen held in and both knees and feet pointing in opposite directions. This position necessitates combination of movements like hip flexion, abduction, and external rotation, knee flexion, and ankle dorsiflexion in a closed kinetic chain position [20]. It compresses one's height to at least 3/4th of their original height [20]. In an attempt to increase the turnout at the hip joint, there is a compensatory increase in lumbar lordosis which places the hip joint in a position where the capsular ligaments are loosened leading to anterior pelvic tilt. This

increased lumbar lordosis elongates the abdominal muscles causing weakness, whereas the erector spinae and hip flexor muscles undergo shortening which further causes an imbalance in the lumbopelvic complex [7].

Natyarambham, another commonly adopted posture by the Bharatanatyam dancer, is the combination of the araimandi position along with arm movements and hand gestures. During the training phase, dancers are instructed to maintain this position for a prolonged duration to improve their strength. Commitment to this level of training typically begins at a very young age and occurs during the adolescent growth spurt involving repetitive movements [3]. In this study, the average minimum age for starting the practice of Bharatanatyam dance form was 6.53 ± 2.34 years. A wrong adaptation of this posture could impose excessive stress on the spine, especially the lumbar spine, and result in pain among the dancers [3].

Development of spinal curvature occurs during the growth phase which is influenced by the stresses placed upon it during performance of any physical activity [21–23]. Amount of training, performance of repetitive movements in a specific pattern and posture adopted are associated with the development of spinal curvatures [21]. Maintenance of a certain type of posture is a requisite and fundamental aspect for a dancer. Hence, they spend maximum time in training to attain appropriate and perfect posture. Literature shows that increased exposure in specific postural position performed frequently for prolonged duration during the adolescent growth can affect the curvature of the spine [21, 23, 24].

It has been reported that pre-professional ballet dancers showed increased anterior pelvic tilt which leads to imbalance in muscular attachments that control the lumbar spine and pelvis. This causes compensatory movements and alteration in the muscle length tension relationship and may predispose to lower extremity injuries [25, 26].

Maintenance of proper posture is primordial for a Bharatanatyam dancer. Hence, it is vital to establish preventive measures to prevent erroneous postural patterns capable of causing pain and injuries. Implementation of

Table 2 Comparison of angles between Bharatanatyam dancers and non-dancers using independent *t* test

Angles (in degrees)	Dancers Mean ± SD	Non-dancers Mean ± SD	P value
Head protrusion	49.23 ± 4.11	50.9 ± 4.11	0.072
Cervical lordosis	31.87 ± 5.83	30.3 ± 6.18	0.245
Thoracic kyphosis	95.73 ± 13.91	92.75 ± 9.49	0.267
Lumbar lordosis	32.83 ± 4.57	40.3 ± 6.31	0.000*
Pelvic tilt	14.28 ± 3.61	8.7 ± 3.01	0.000*

*$p \leq 0.05$ is statistically significant

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postural re-education, muscular balance, and flexibility is a prerequisite for these highly trained professionals. It indicated the need for physiotherapeutic intervention in order to contribute to the kinetic functional balance of Bharatanatyam dancers.

In this study, assessment of posture was performed using photogrammetric method using Kinovea software in the dance academy where it was easy to access these professional dancers. Small sample size due to limited number of a highly specialized population, female Bharatanatyam dancers was the limitation of the study. We did not study the association between postural changes with the musculoskeletal pain in dancers which can be the future scope. However, as these results are the first in the literature to report postural profile in Bharatanatyam dancers, further longitudinal research is needed to study changes in posture, flexibility, and range of motion over time.

Conclusions

The findings in this study show that there is increased lumbar lordosis and anterior pelvic tilt in Bharatanatyam dancers. Prolonged practice at younger age results in alteration in the body alignment and posture.

Abbreviations

ASIS: Anterosuperior iliac spine; PSIS: Posterosuperior iliac spine

Authors' contributions

VP has contributed to the concept, design, literature search, data collection and analysis, manuscript preparation, editing, and review. PW has contributed to the concept, design, literature search, manuscript preparation, editing, and review. AS has contributed to the design, literature search, data collection and analysis, and manuscript preparation. The authors have read and approved the final manuscript.

Availability of data and materials

The data sets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The Institutional Research Review Committee, Mahatma Gandhi Mission's, College of Physiotherapy, Navi Mumbai (Reference no: MGM/COP/IRRC/134/2019) approved the study. Written informed consent was obtained from each participant in the language understood by them before commencing the study.

Consent for publication

N/A.

Competing interests

The authors declare that they have no competing interests.

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