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RESEARCH ARTICLE

ASSESSMENT OF BODY BALANCE IN FEMALE BHARATHANATYAM DANCERS

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ABSTRACT

Background: Bharathanatyam is an Indian classical dance form which involves rhythmic dance movements. There are various postures in this dance form to attain which dancers need optimum muscle strength and adequate range of motion at required joints. Dancers need good body balance to maintain these postures. Dancers also have to maintain balance while movements and changing postures.
Objective: To assess and compare static and dynamic balance in female bharathanatyam dancers and nondancers.
Methods: 32 dancers and 33 nondancers were randomly selected from various Bharathanatyam dance schools and general population in Bengaluru respectively. Height, weight, BMI and lower limb length were measured. Static balance was assessed by balance error scoring system. Dynamic balance was assessed by star excursion balance test. Data was analysed and presented as Mean±standard deviation.
Results: The independent sample t test was applied for statistical analysis. $P<0.05$ was considered significant. Dancers performed fewer errors than nondancers ($P<0.001$). Dancers had lower reach distances with both right and left legs compared to nondancers ($P<0.001$).
Conclusion: This study showed that dancers had superior static balance and inferior dynamic balance compared to nondancers.

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INTRODUCTION

Bharathanatyam is an Indian classical dance form. It involves NRITTHA which is rhythmic dance movements, NATYA which is dance in dramatic aspect and NRITHYA which is a combination of both. There are various types of abhinayas of which ANGIKA is physical or body movements. ARAMANDI is the most basic position in bharathanatyam which is similar to Demiplie position of ballet dancers (Anbarasi, *et al.,* 2012). Here knees are flexed and there is abduction and external rotation at hip joints (Anbarasi, *et al.,* 2012). There are various such positions in bharathanatyam to attain which dancers need optimal muscle strength and adequate motion at the required joints. Dancers also require balance to maintain position and also while continuously changing postures and positions. Flexibility is considered as an essential element of normal biochemical functioning in sport (Anbarasi, *et al.,* 2012). The process of maintenance of balance is complex and involves the co-ordination of sensory, motor and biomechanical components in order to keep the centre of gravity over a relatively small base of support. The maintenance of balance occurs by a combination of visual clues, clues from vestibular system and proprioceptors.

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The population of dancers is unique because they are not merely athletes whose work intensity is no less than a football player but also they are artists who constantly strive to perfect the subtle and aesthetic details in performance (Anbarasi, *et al.,* 2012). There are huge number of Professional dancers and countless amateur dancers or recreational dancers and they are a unique group of athletes with aesthetic nature of sport (Hoch *et al.,* 2011). Dynamic balance is the ability of an individual to maintain stability of the centre of mass during movement. As an inherent component of many sporting activities, it is an important construct to examine relation to injury risk (Butler *et al.,* 2012). Static balance is defined as the ability to maintain base of support with minimal movement (Bressel *et al.,* 2007). Each sport requires different levels of sensorimotor processes to perform skills and protect neuromuscular system from injury (Bressel *et al.,* 2007). Gymnasts perform leaping and tumbling manoeuvres as well as static poses while barefoot on surfaces varying in stiffness (Bressel *et al.,* 2007). In dancers, high incidence rates of musculoskeletal injuries have been reported mainly in the lower extremities and back, predominantly soft tissue lesion and overuse injuries. Various potential risk factors for dancers have been suggested ranging from physical overload to psychological distress, however, conclusive evidence of any reported risk factor is lacking (Scheper *et al.,* 2013). The core stability and strength enhancement may

possibly improve athletic performance and reduce incidence of injury (Kang *et al.,* 2013). The relationship between age and physical ability is a major characteristic of human development (Nassif *et al.,* 2012). Balance or Postural control is a necessary component of activities of daily living and sport. Various instrumented devices are available to assess static balance. Clinicians do not often have access to instrumented balance testing devices. The Balance Error Scoring System (BESS) consists of three stances – Double limb, Single limb and Tandem performed on two surfaces – Firm and Foam (Bell *et al.,*2011). Star Excursion Balance Test (SEBT) was originally described by Gray as a rehabilitative tool, the SEBT is a series of single limb squats using the nonstance limb to reach maximally to touch a point along 1 of 8 designated lines on the ground (Gribble *et al.,* 2012). There is a huge lacuna in the area of dance medicine in relation to the Indian classical dance (Anbarasi, *et al.,* 2012). There is a lack of research work done specifically on Indian classical dancers and in their own context it acts as a great impediment in providing scientific recommendations to prevent injuries and offer right treatment (Anbarasi, *et al.,* 2012). The traditional practices of the dancers need to be carefully studied and juxtaposed with the modern system of physical training. This study has been taken up with the hypothesis that dancers have better balance compared to nondancers.The objectives of the study are:

- To assess static balance and to compare static balance of dancers with nondancers.
- To assess dynamic balance and to compare dynamic balance of dancers with nondancers.

MATRIALS AND METHODS

Source of data

Bharathanatyam dancers were randomly selected from various Bharathanatyam dance schools from Bengaluru and Non dancers were selected from General population. Approval and clearance from the institutional ethics committee was obtained before starting the study. The written informed consent was obtained from the subjects in the prescribed format in English.

Inclusion criteria for dancers

- Female bharathanatyam dancers in the age group of 18-23 years.
- Dancers with formal training in bharathanatyam for minimum of 5 years and currently practicing for atleast for 6 hours a week.

Inclusion criteria for non dancers

- Normal healthy sedentary female subjects who are in the same age group and BMI matched.

Exclusion criteria

- Subjects with history of injury in past 1 year.
- Pregnant subjects.

Study procedure

A written informed consent was taken from all the subjects. History regarding the general health status was taken. Questions regarding practice of dance and sports activities were administered to all the subjects. Height and Weight were measured and BMI was calculated. The lower limb length was measured from Anterior superior iliac spine to Medial malleolus. Based on the answers given by the subjects to the questions administered, those who fulfil inclusion criteria for dancers were included under dancers category and those who fulfil inclusion criteria for non dancers were included under non dancers category. As described in the standard protocol of the test, time was given to familiarise with the test procedure for all the subjects.

Table 1. Tests used in the study

Domain	Function	Test
Balance	Static balance	Balance error scoring system
	Dynamic balance	Star excursion balance test

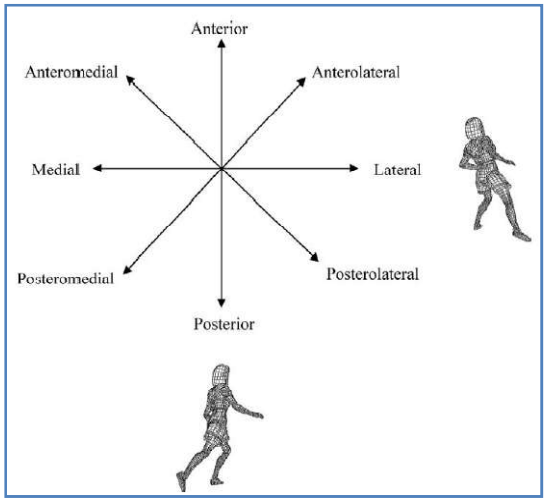

Figure 1. Star excursion balance test

Balance error scoring system

The balance error scoring system (BESS) is a test to assess the static balance. It consists of 6 positions on two support surface which are firm and foam. 3 stances are maintained on firm surface and on foam. They are double leg stance, single leg stance and tandem stance (heel to toe). The subject has to position into designated stance with hands on the hips and has to close the eyes. The trial begins when the subject closes the eyes and the subject has to maintain the position for 20 seconds. Three trials of all six positions are done by all the subjects. Based on the error performed, the error score is given to the subject. The error scores are added to give the final score.

0 – No error
1 – Opening eyes
2 – Hand lifted off the hips
3 – Step, Stumble or Fall
4 – Moving hip to more than 30º abduction
5 – Lifting forefoot or heel
6 – Remaining out of test position for more than 5 seconds

Star excursion balance test: The star excursion balance test (SEBT) is a test to assess the dynamic balance. Here the subject has to maintain a stable single leg stance with stance leg or the test leg and reach for the maximum distance with the other leg which is the reach leg in 8 directions.

Table 2. Comparison of Anthropometric data between nondancers and dancers

* = Significant

Variables	Non-dancers group N=33			Dancers group N=32			Difference in mean	't'-value	P-value
	Range	Mean±SD	SE	Range	Mean±SD	SE			
Age	23-18	21.8±1.55	0.27	23-18	20.09±2.15	0.38	1.71	3.72	P<0.001*
Height	167-146	158.7±5.27	0.63	178-152	161.2±5.17	0.91	2.5	1.89	0.063
Weight	84-39	58.49±10.9	1.91	82-46	60.55±8.29	1.46	2.06	0.859	0.393
BMI	30.6-16.6	23.08±3.62	0.63	30.1-18.4	23.15±3.04	0.54	0.07	0.08	0.933
Lower limb length	100-78	86.48±5.63	0.98	100-80	89.03±5.06	0.89	2.54	1.91	0.06

Table 3. Mean years of learning and Mean practice hours per week in dancers

* = Significant

	Dancer group		
	Range	Mean±SD	SE
Year of learning	15-5	8.68±2.61	0.46
Practice in hours per week	8-6	6.31±0.53	0.09

Table 4. Comparison of Error scores of nondancers and dancers on 2 surfaces and total score by BESS

* = Significant

Variables	Non-dancers group N=33			Dancers group N=32			Difference in mean	't'-value	P-value
	Range	Mean±SD	SE	Range	Mean±SD	SE			
Flat	9-0	4.48±2.52	0.44	6-0	1.59±1.92	0.39	2.89	5.18	P<0.001*
Foam	12-5	9.09±2.15	0.38	12-3	5.75±1.85	0.33	3.34	6.69	P<0.001*
Composite	21-5	13.57±3.84	0.67	15-3	7.34±2.85	0.505	6.23	7.403	P<0.001*

Table 5. Comparison of reach distances with right limb between nondancers and dancers

* = Significant

Right reach (%)	Non- Dancer N=33			Dancer N=32			Difference in mean	't'-value	P-value
	Range	Mean±SD	SE	Range	Mean±SD	SE			
Anterior	92.6-60	77.26±7.17	1.27	95.9-48.8	70.22±10.47	1.82	7.04	3.15	0.002**
Antero medial	98.8-64	78.38±7.75	1.37	98.2-56.6	71.08±10.91	1.9	7.30	3.09	0.002**
Medial	91.7-64	76.39±6.52	1.15	98.2-57.7	71.18±9.55	1.66	5.21	2.56	0.012*
Postero medial	90.6-66.1	75.72±5.46	0.97	97.6-52.2	67.75±10.6	1.84	7.96	3.78	P<0.001***
Posterior	82-56	69.09±6.63	1.17	93.2-37.2	61.76±11.54	2.01	7.33	3.12	0.002**
Postero lateral	83.1-48.8	67.24±7.74	1.37	89.5-34.4	58.28±10.98	1.91	8.95	3.78	P<0.001***
Lateral	73.9-38	62.2±9.03	1.59	78.3-30	54.31±10.93	1.90	7.89	3.16	0.002**
Antero lateral	93.2-65	74.31±6.94	1.23	98.1-49.4	67.14±10.8	1.88	7.16	3.16	0.002**
Right composite	656-498	580.72±37.46	6.62	727-381	521.78±78.34	13.63	58.93	3.84	P<0.001***

Table 6. Comparison of reach distances with left limb between nondancers and dancers

Left reach (%)	Non- Dancer N=33			Dancer N=32			Difference in mean	't'-value	P-value
	Range	Mean±SD	SE	Range	Mean±SD	SE			
Anterior	90.4-60.8	74.38±6.01	1.06	98.8-53.8	70.17±10.69	1.86	4.20	1.94	0.054
Antero medial	98.8-60.8	76.46±7.39	1.31	93.9-56.4	70.43±9.01	1.57	6.04	2.94	0.004**
Medial	91.5-64.7	74.56±5.32	0.93	97.5-55.7	70.01±9.43	1.64	4.54	2.38	0.02*
Postero medial	98-58	74.88±7.25	1.28	94-53	66.45±10.05	1.75	8.42	3.86	P<0.001***
Posterior	89.2-50	68.12±6.81	1.2	93.9-44.6	61.12±10.88	1.89	7	3.09	0.002**
Postero lateral	85-48.8	66.38±7.43	1.31	87.6-35.3	58.66±11.99	2.08	7.71	3.101	0.002**
Lateral	75-38	61.18±8.75	1.54	88.9-26.6	55.22±11.33	1.97	5.96	2.37	0.02*
Antero lateral	88-65.9	73.53±5.13	0.908	99.4-53.2	67.07±10.8	1.88	6.45	3.05	0.003**
Left composite	654.3-477.1	569.48±38.8	6.86	711.3-393.2	519.11±75.22	13.09	50.37	3.37	0.001**

The same is repeated for the other leg also. The 8 directions are anterior, antero lateral, lateral, postero lateral, posterior, postero medial, medial and antero medial. (Figure 1) The subject has to reach without using the leg for support. In order to successfully complete the attempt, the subject has to maintain reach for 1 second and come back to starting position that is both feet together without touching each other. Again from the starting position the subject has to attempt for reach in the next direction. For right limb stance medial is to the left side and for left limb stance medial is to the right side. For reaching in the posterior directions the subject has to move reach leg behind the stance leg. Excursion length (reach length) is normalized to the limb length and expressed as percentage.

(Excursion length ÷ Limb length) X 100

The subject is given 2 minutes to familiarize with the test and then three trials are done with each leg.

RESULTS

Dancers performed fewer errors compared to nondancers on flat surface as well as on foam and there was significant difference in the composite score as well.

Table 7. Comparison between right and left reach distances in dancers

Variables (%)	Right reach			Left reach			Difference in mean	't'-value	P-value
	Range	Mean±SD	SE	Range	Mean±SD	SE			
Anterior	92.6-60	77.26±7.17	1.27	90.4-60.8	74.38±6.01	1.06	2.89	3.71	P<0.001*
Antero medial	98.8-64	78.38±7.75	1.37	98.8-60.8	76.46±7.39	1.31	1.92	1.87	0.072
Medial	91.7-64	76.39±6.52	1.15	91.5-64.7	74.56±5.32	0.93	1.83	2.34	0.025*
Postero medial	90.6-66.1	75.72±5.46	0.97	98-58	74.88±7.25	1.28	0.84	0.74	0.467
Posterior	82-56	69.09±6.63	1.17	89.2-50	68.12±6.81	1.2	0.97	0.83	0.41
Postero lateral	83.1-48.8	67.24±7.74	1.37	85-48.8	66.38±7.43	1.31	0.86	0.78	0.441
Lateral	73.9-38	62.2±9.03	1.59	75-38	61.18±8.75	1.54	1.02	1.06	0.294
Antero lateral	93.2-65	74.31±6.94	1.23	88-65.9	73.53±5.13	0.908	0.78	0.935	0.357
Composite	656-498	580.72±37.46	6.62	654.3-477.1	569.48±38.8	6.86	11.23	3.17	0.003*

Table 8. Comparison between right and left reach distances in nondancers

Variables (%)	Right reach			Left reach			Difference in mean	't'-value	P-value
	Range	Mean±SD	SE	Range	Mean±SD	SE			
Anterior	95.9-48.8	70.22±10.47	1.82	98.8-53.8	70.17±10.69	1.86	0.05	0.04	0.961
Antero medial	98.2-56.6	71.08±10.91	1.9	93.9-56.4	70.43±9.01	1.57	0.66	0.517	0.608
Medial	98.2-57.7	71.18±9.55	1.66	97.5-55.7	70.01±9.43	1.64	1.17	1.53	0.137
Postero medial	97.6-52.2	67.75±10.6	1.84	94-53	66.45±10.05	1.75	1.3	1.39	0.17
Posterior	93.2-37.2	61.76±11.54	2.01	93.9-44.6	61.12±10.88	1.89	0.63	0.63	0.53
Postero lateral	89.5-34.4	58.28±10.98	1.91	87.6-35.3	58.66±11.99	2.08	0.38	0.34	0.736
Lateral	78.3-30	54.31±10.93	1.90	88.9-26.6	55.22±11.33	1.97	0.906	0.938	0.35
Antero lateral	98.1-49.4	67.14±10.8	1.88	99.4-53.2	67.07±10.8	1.88	0.07	0.12	0.904
Right composite	727-381	521.78±78.34	13.63	711.3-393.2	519.11±75.22	13.09	2.67	0.69	0.494

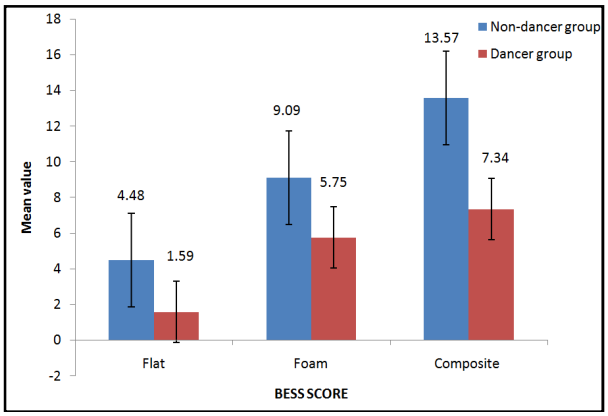

Figure 2. Mean error scores of nondancers and dancers by BESS

Nondancers had higher reach with right leg in all directions compared to dancers and this difference was statictically significant. The total reach (composite) was higher in nondancers compared to dancers. Nondancers had higher reach in all 8 directions with left leg compared to dancers as well as the composite reach. This difference was statistically significant except in anterior direction. In dancers, right leg reach was higher than left leg reach in all directions and the composite reach. The difference was statistically significant in anterior, medial and composite reach. In nondancers, there was no significant difference between reach of right leg and left leg.

DISCUSSION

There are large numbers of professional, amateur and recreational dancers in the world. There are various dance forms. Dance is a good form of exercise and is considered as a sport. Ballet, jazz, salsa etc are western dance forms. There are many classical dance forms in India. There are very few studies in these forms. This is one of the few studies that are assessing the kinetic parameters like balance, in bharatahanatyam dancers. Table 2 gives the anthropometric data of the subjects. The mean years of learning bharathanatyam dance and practice hours per week of dancers is given in Table 3.

Static Balance

In our study, dancers made fewer errors compared to nondancers on flat surface as well as on foam. The total error score as assessed by BESS was lesser in dancers compared to nondancers (Table 4, Figure 2). Dancers are proposed to have superior balance compared with physically active nondancers and this may reduce their risk for ACL injury. Enhanced balance can decrease musculoskeletal injury risk. In a study by Ambegaonkar *et al.,* 2013 dancers performed fewer errors on BESS than did nondancers. This study showed dancers had greater balance than did nondancers in this test (Ambegaonkar *et al.,* 2013). The results were similar to our study where in bharathantyam dancers performed fewer errors than nondancers and this is probably due to the dance training programme. Whether balance differences exist among female dancers, soccer and basketball athletes was investigated by Cortes *et al.,* 2014 Balance can impact ACL injury risk and is related to neuromuscular control during movement. Balance as assessed by BESS was similar among athletes participating in different sports (Cortes *et al.,* 2014). The results of our study was in correlation with this study. Dancers' static balance was same as athletes from other sporting events showing that there must be a unique sensorimotor challenge faced by each group which helps them to improve balance. In a study by Bressel E et al, where static balance was compared between female collegiate soccer, basketball and gymnastics athletes. Here gymnasts and soccer players did not differ in terms of static balance. Basketball players displayed inferior static balance compared with gymnasts. The statistical differences observed

among sports may, in part, be related to the unique sensorimotor challenges imposed by each sport. Gymnasts often practice motionless balance skills on the balance beam, similar to skills required in the BESS. Hence, gymnasts may develop superior attention focus on cues that alter balance performance, such as small changes in joint position and acceleration. In contrast, basketball players rarely balance motionless on one leg and often attend to ball and player position cues. Their static balance might be less developed than that of gymnasts (Bressel *et al.,* 2007) Similarly, bharathanatyam dancers perform various static poses thus making few errors in BESS.

Dynamic balance

In our study, dancers had lower reach with right leg in all directions as well as composite reach compared to nondancers (Table 5). The dancers have lower reach with left leg in all directions and composite reach (Table 6). In dancers, the right leg reach was higher in all directions as well as composite reach compared to left leg (Table 7). There was no significant difference between right and left leg reach in nondancers (Table 8). SEBT is more dependent on neuromuscular characteristics such as lower extremity coordination, flexibility and strength. Long term athletic training augments neurosensory pathways and stimulates cutaneous nerve receptors or mechanoreceptors in the muscles, ligaments and joint capsule of knee and ankle joint as demonstrated by improved balance and proprioception (Bhat *et al.,* 2013). In a study, Balance comparisons between female dancers and active nondancers by Ambegaonkar et al. dynamic balance was assessed by SEBT and modified Bass test of dynamic balance. In contrast to our study dancers had greater SEBT reach distance in some directions. Bass scores were similar between groups. Here, dancers had greater balance in some but not all tests. Although dancing may improve balance as compared with not dancing at all, it is not better than physical activity in improving balance (Ambegaonkar *et al.,* 2010). our study involved bharathanatyam dancers in contrast to the above study.

Poor performance on the SEBT may be related to an increased risk for sustaining a noncontact lower extremity injury over the course of a competitive American football season. College football players should be screened preseason using the SEBT to identify those at an elevated risk for injury based upon dynamic balance performance to implement injury mitigation strategies to this specific subgroup of athletes (Butler *et al.,* 2013). The dancers in our study have lower dynamic balance and this may make them more prone for injuries. Following an 8 weeks neuromuscular training program that focused on core stability and lower extremity strength in female soccer players showed significant improvement in SEBT composite score on both right and left lower limbs. There was no change in the SEBT composite score for right or left limb in the control group (Filipa *et al.,* 2013). Comparison of dynamic balance in female collegiate soccer, basketball, and gymnastics athletes showed that basketball players displayed inferior dynamic balance compared with soccer players. Gymnasts had lower reach distances as compared to soccer players but the difference was not significant. (Bressel *et al.,* 2007) This result was akin to our study but then our study showed significant difference between dancers and nondancers. The details of physical activity of nondancers were not known.

Soccer players often perform single-leg reaching movements outside their base of support during passing, receiving, and shooting, which may in part explain why their dynamic balance was better than basketball players. Dynamic balance scores were not different between soccer players and gymnasts, some sensorimotor challenges may be common in these two sports (Bressel *et al.,* 2007). The bharathanatyam dancers do not undergo training programme like that of soccer players which may partly explain the lower reach distances in SEBT. Correct balance is imperative for both football and field hockey players as football players require to maintain single limb balance while performing on field. Consequently, football players are expected to have better unipedal stability than athletes in other sports. Although field hockey players use their upper extremity, proper balance of head, feet and hand with the stick is necessary to be maintained to perform these quick and skill the movements. It is required for a player to seek a point of balance in relation to the ball with every technique. The faster reaction time in field hockey players than the athletes of other sports could be one of the supporting factors for better dynamic balance performance. (Bhat and Moiz, 2013) In contrast to this, dancers had lower dynamic balance as the training technique is different from that of hockey or football and the reaction time while dancing which is not assessed in this study may affect the dynamic balance.

Limitations

Our study involved a small group of dancers and nondancers only females were included in this study. So it difficult to generalise the results of this study to whole dancers' population as it involves both male and female dancers. Detailed history of physical activity of dancers and nondancers was not obtained.

Conclusion

Bharathanatyam dancers displayed superior static balance and inferior dynamic balance compared to nondancers. Additional neuromuscular training programs may be implemented to improve dynamic balance in dancers and further research is required to follow up such cases.

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