GROUND REACTION FORCES DURING TATTA ADAVU OF BHARATANATYAM

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The purpose of the study was to establish the normative values for vertical ground reaction forces during the most basic step of Bharatanatyam dance. Bharatanatyam involves rthymic tapping of the feet with varying trunk, upper extremity, and hand movements. These dancers are prone to lower extremity injuries. However, there is very little insight into the physical demands of the dance form. Seven experienced Bharatanatyam dancers performed the *tatta adavu* by tapping their feet repeatedly on a force plate at 2 speeds. Peak ground reaction force was found to be 4 to 5 times the body weight. These high forces repeatedly experienced by the lower extremities could contribute to the higher incidence of lower extremity injuries. Further biomechanical analysis of these dance movements must be undertaken to understand the complexities of the dance form.

KEYWORDS: kinetics, bharatanatyam, dance, ground reaction force

INTRODUCTION: Bharatanatyam is one of the oldest traditional classical dance forms from India. It is practiced widely throughout the world. Over the past few decades, Bharatanatyam has evolved into a competitive dance form. Bharatanatyam, essentially, involves the rhythmic tapping of the feet in different postures of the body that are complimented by hand movements and facial expressions. The basic steps of Bharatanatyam are called *adavus*. The choreographies are a combination of the *adavus* that vary in speed, hand gestures, and expressions. Despite being a popular dance form, there is very little insight into the physical demands of the dance form. The dancers are prone to lower extremity injuries, especially the knee joint (Paul & Kapoor, 1998). Till date, no study has been conducted to analyse the biomechanical demands of this dance form. This study was conducted to provide normative values of ground reaction forces experienced by the dancers at two different speeds of the most basic foot tapping step – *tatta adavu*

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METHODS: The study was approved by the institutional research and ethics committee.

Participants:

Seven experienced dancers volunteered for the study. Criteria for inclusion was that the dancer must be at least 18 years of age, have at least 5 years of experience, and practice the dance at least 2 times a week. The criteria for exclusion was any injury in the past 6 months or surgeries in the past year. The dancers were also excluded if they practiced any other dance form to avoid adulteration.

Equipment:

A single force platform (AMTI BP400600, Advanced Mechanical Technology, Inc., Watertown, MA) were used to collect the peak ground reaction force 1000 Hz. The analog signal was amplified using the Gen5 Optima amplifier. Netforce software was used to assimilate and export the data.

Procedure:

The dancers did a 10 minute warm up before the session. The dancers attained the *ardhamandala* posture (see figure 1) which is most commonly used in Bharatanatyam dance. The dancers performed the *tatta adavu* step (alternate foot tapping) in *ardhamandala/ araimandi posture* (see figure 1) at two speeds – 49 beats per minute and 200 beats per minute. The dancers performed the step with only one foot on the force plate at a time. And repeated the movement with the other foot on the force plate. Peak vertical ground reaction force was obtained. Average of the peak vertical ground reaction force of three trials was considered. The data was analysed using R and presented as descriptive statistics.

Figure 1: A dancer performing Tatta Adavu in the Ardhamandala posture

RESULTS: The demographics of the participants is listed in Table 1. The mean peak vertical ground reaction force expressed in multiples of body weight (BW) in presented in Table 2.

Table 1: Mean (SD) Subject Demographics

Number	7
Gender	Female
Age (years)	21.4 (5.2)
Height (centimetres)	165.46 (9.68)
Body mass (kilogram)	56.25 (12.01)
Dance Experience (Years)	14.2 (4.5)

Table 2: Mean (SD) Peak GRFV / Body Weight

Speed 1		Speed 3	
Left	Right	Left	Right
4.55 (1.93)	4.42 (1.48)	5.12 (1.75)	5.08 (1.76)

DISCUSSION: This was a first of a kind study looking into the biomechanics of the Bharatanatyam dance form. No previous studies have analysed the forces passing through the lower extremities during Bharatanatyam. Very few studies have looked into other foot tapping or percussive dance forms such as tap (Mayers et al, 2010). Therefore, in this study we have compared the dance form to tap dance and other sports. The vertical ground reaction force (GRF-V) during *tatta adavu* can be approximately 4-5 times the body weight. It is 2-3 times that of the GRF-V during tap dance and aerobic dance (Mayers et al, 2010; Wu et al, 2012). It is very close to that of a rebound jump landing during basketball (Mcnair & Prapavessis, 1999; Nigg, 2001)

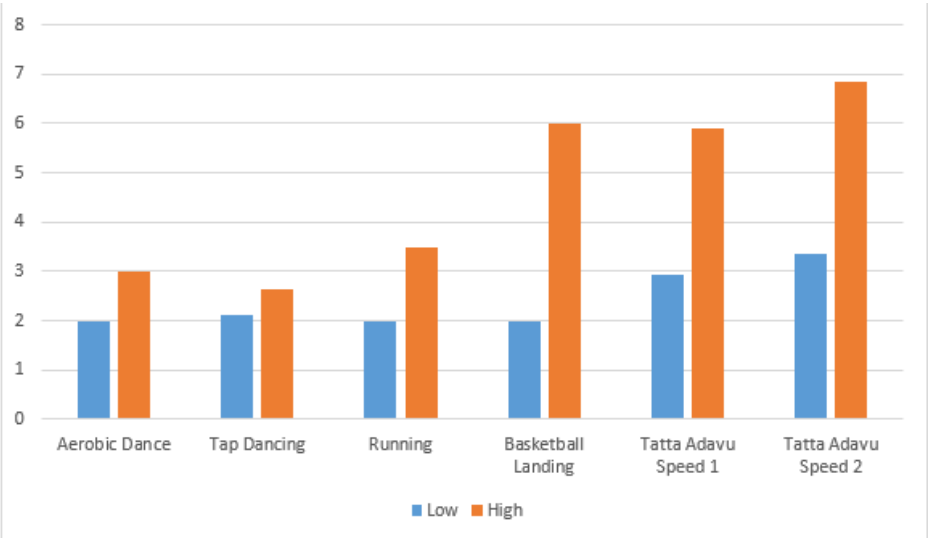

Figure 2: Comparison of GRF-V of Various Activities

Bharatanatyam dancers are prone to lower extremity injuries, especially the knee joint. The sheer amount of force passing through the lower extremities may contribute to the injuries.[5] The dancers perform the taps constantly in varying speeds throughout the recital. A typical recital could last a minimum of an hour. This intensity of foot tapping along with vigorous upper extremity movements could further contribute to lower extremity injuries. A further biomechanical analysis of the dance form is needed to gain a deeper understanding of the dance form. With better insight into the physical demands of the dance, the dance teachers could train their dancers better to avoid injuries.

CONCLUSION: Bharatanatyam is a popular dance form that has been overlooked by the scientific community. Although many dancers currently practice Bharatanatyam for fitness and a means to stay physically active, there is very little insight into the biomechanics of Bharatanatyam dance. This study revealed that during the foot tapping in Bharatanatyam about 4-5 times the body weight of ground reaction force is experienced by the dancer. These high impact forces could contribute to the injuries. Further research into the biomechanics and physical demands of the dance form is needed for improved training of dancers and prevention of injuries.

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