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Association between Anthropometric Measures and Musculoskeletal Injuries in Bharatnatyam Dancers: A Cross-Sectional Study

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ABSTRACT

Background: Bharatanatyam, a classical Indian dance form, is known for its intricate movements and poses that demand significant physical and psychological endurance. Despite its cultural importance, there is a notable lack of recent data on musculoskeletal (MSK) injuries in Bharatanatyam dancers, particularly concerning the role of anthropometric measures such as Body Mass Index (BMI) and other body circumferences.
Objective : This study aimed to determine the association between anthropometric measures and the occurrence of musculoskeletal injuries in Bharatanatyam dancers.
Methods: A cross-sectional study was conducted on 96 Bharatanatyam dancers aged 15-25 years from various dance centers across Aurangabad District. Anthropometric measures, including BMI, waist-hip ratio (WHR), and circumferences of the waist, hip, abdomen, and thigh, were recorded. The incidence of musculoskeletal injuries was assessed using the Bharatnatyam dance injury pain questioners (BDIPQ).
Results: The study revealed a significant correlation between higher BMI and an increased incidence of knee and ankle injuries ($p < 0.0001$). However, no significant correlation was found between hip circumference, waist circumference, abdominal circumference, thigh circumference, and the occurrence of musculoskeletal injuries. The results highlight that dancers with a higher BMI are at a greater risk of certain MSK injuries.
Conclusion: These findings suggest that higher body mass may contribute to a higher risk of specific musculoskeletal injuries in Bharatanatyam dancers. The study underscores the need for targeted injury prevention strategies, particularly for dancers with a higher BMI, to enhance the longevity and performance of this ancient dance form

Key words: BDIPQ, BMI, WHR, & Bharatanatyam dancers

INTRODUCTION

Bharatanatyam, an ancient dance form, is renowned for its magnificent, expressive, and sculpturesque poses that require high levels of physical and psychological power to execute. (1) There are three divisions in Bharatanatyam. It involves Nrittha which is rhythmic dance movements, Natya which is dance in dramatic aspect and Nrithya which is a combination of both.78% of professional Bharatanatyam dancers in Maharashtra report having sustained musculoskeletal injuries. (2)

Bharatanatyam is one of India's oldest classical dance forms, combining intricate footwork, elaborate hand gestures, and expressive facial expressions to narrate stories. This art form requires physical endurance, flexibility, and precision, with dancers spending several hours mastering techniques and performing complex routines. However, the intense physical demands of Bharatanatyam predispose dancers to musculoskeletal injuries, which can affect their ability to perform and lead to long-term health implications. (3)

The repetitive nature of Bharatanatyam movements, including deep knee bends, leaps, and prolonged static postures, places significant stress on the musculoskeletal system. Studies suggest that improper technique, overtraining, and inadequate recovery periods are key contributors to these injuries (Koutedakis& Sharp, 2004). (4) Additionally, anthropometric measures, such as Body Mass Index (BMI), Waist-to-Hip Ratio (WHR), and circumferences of specific body regions, may influence the risk of injuries by altering joint loading, biomechanical efficiency, and movement patterns (Rickman AM, et al, 2012).(5)

While anthropometric factors are well-documented in athletes, limited research has been conducted to explore their impact on classical dancers, particularly Bharatanatyam performers. Studies in other forms of performing arts have shown that variations in BMI and body composition can influence injury prevalence and severity, emphasizing the need for body-specific injury prevention strategies (Bowerman et al., 2015; Laws, 2005).(6) In Bharatanatyam, the cultural and aesthetic expectations of maintaining certain body proportions further highlight the importance of understanding the relationship between anthropometric measures and musculoskeletal health.

There is a lack of the latest data on musculoskeletal injuries in Indian classical [IC] dance because the majority of current research on dance injuries has focused on ballet. Few research has looked into the type and extent of the relationship between body mass index (BMI) score and the risk of musculoskeletal (MSK) injury. Few studies have integrated them to investigate their interplay This level of customization is relatively novel in the field of dance medicine. (7)

Aim of this study is To determine the association between anthropometric measures and musculoskeletal injuries in Bharatanatyam dancers. There are two objectives of this study, which are To find out if certain anthropometric measurements and the frequency of musculoskeletal injuries are related and to determine whether anthropometric measurements can foretell a dancer's risk of musculoskeletal injuries.

MATERIALS AND METHODS

This cross-sectional observational study was conducted in 96 Bharatanatyam dance aged 15-25 years of Private Dance centers across the Aurangabad District, Maharashtra. Ethical clearance was obtained from the institutional ethical committee of MGM. Medical College, Chhatrapati Sambhaji Nagar, Maharashtra. Purposive sampling technique was used. A written accent form was taken from all the study participants. The Inclusion criteria for the study were, Bharatanatyam dancers living

in Chhatrapati Sambhaji Nagar, 15-25 Years old Female, 3 years of consecutive dance training experience and Performs dance 3-5 hours/week. Bharatanatyam Dancers with psychological and cognitive impairment, Subjects unwilling to participate in the study, Presence of congenital deformities (e.g.: Kyphosis, Lordosis), Any recent trauma (e.g.: RTA, fractures) and any recent surgeries (e.g.: Limb and spine surgeries)

OUTCOME MEASURES

1. Bharatanatyam dance injury and pain questionnaire (BDIPQ)

- Bharatanatyam, an ancient dance form, is renowned for its magnificent, expressive, and sculpturesque poses that require high levels of physical and psychological power to execute.
- The bharatanatyam dance injury and pain questionnaire (BDIPQ) [9] is an assessment tool designed to inquire about pain experiences and the influence of injuries during the practice of Bharatanatyam techniques. It aims to highlight the connection between technique-related injuries and its consequences on the dancer's overall performance and well-being.

INTERPRETATION

- If you answered “YES” you get 0 point
- If you answered “NO” you get 1 point
- 0-1: Minimum disability during dance performance
- 2-4: Mild disability during dance performance
- 5-7: Moderate disability during dance performance
- 8-9: Severe disability during dance performance
- The BDIPQ demonstrated excellent validity (S-CVI = 0.91, Modified Kappa = 0.76–1.00) and reliability (Pearson r = 0.9702, Cronbach’s $\alpha = 0.84$), confirming its robustness and consistency.

2. Body Mass Index (BMI)

- Height Measurement:
  - Measured using a stadiometer with the participant standing barefoot, heels together, arms at their sides, and looking straight ahead.
  - Height was recorded to the nearest 0.1 cm.
- Weight Measurement:
  - Measured using a calibrated digital weighing scale with the participant standing barefoot and in a relaxed position.
  - Weight was recorded to the nearest 0.1 kg.
- Calculation: BMI was calculated using the formula: BMI=Weight (kg)/Height (m)2

3. Waist-to-Hip Ratio (WHR)

- Waist Circumference:
  - Measured at the narrowest point between the lower rib and the iliac crest using a non-stretchable tape measure.
  - If no obvious narrowest point was present, the measurement was taken 1 inch above the navel.
  - Participants stood with feet shoulder-width apart and arms relaxed at their sides. Measurements were taken at the end of a normal exhalation.
- Hip Circumference:
  - Measured at the widest point of the buttocks using the same tape measure.
- Calculation:
  - WHR was calculated using the formula: WHR=Waist Circumference (cm)/ Hip Circumference (cm)

4. Abdominal Circumference

- Measured at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest, parallel to the floor.
- The tape measure was snug but not compressing the skin, and the participant was instructed to breathe normally.
- Measurement was recorded to the nearest 0.1 cm.

5. Thigh Circumference

- Measured at the midpoint between the inguinal crease and the proximal border of the patella (knee cap).
- The participant stood upright with feet slightly apart and weight distributed evenly.
- The tape measure was placed perpendicular to the length of the thigh and snug but not tight.
- Measurement was recorded to the nearest 0.1 cm.

Quality Control

- All measurements were taken three times by the same trained examiner, and the average of the three readings was used for analysis.
- Calibration of equipment (e.g., tape measure, weighing scale) was performed prior to data collection.
- To ensure reliability, a subset of measurements was independently repeated by another trained assessor.

STATISTICAL ANALYSIS:

Data was collected from 96 children. Statistical analysis was done by SPSS software version 20.0 using Pearson's correlation coefficient test. P<0.001 was considered to be statistically significant.

RESULT

Table no. 1Comparison of Anthropometric measures and musculoskeletal injury in Bharatnatyam dancers

Outcomes	Mild	Moderate	T value	P value
BMI	21.26 ± 4.06	21.85 ± 4.4	26.692	<0.0001
Waist circumference	80.78 ± 9.2	81.58 ± 8.7	16.830	<0.0001
Hip circumference	95.007 ± 12.7	97.8 ±12.8	36.942	<0.0001
WHR	0.84 ± 0.05	0.83± 0.05	36.689	<0.0001
Abdominal Circumference	71.93 ± 9.6	73.62 ± 9.5	1.012	0.3220
Thigh Circumference	45.83 ± 13.8	50.54 ± 21.1	0.5490	0.5883

A comparison of anthropometric measures between Bharatanatyam dancers with mild and moderate musculoskeletal injuries. The BMI was slightly higher in the moderate injury group (21.85 ± 4.4) compared to the mild injury group (21.26 ± 4.06), showing a statistically significant difference (T-value: 26.692, P < 0.0001). Waist circumference also demonstrated a significant increase in the moderate group (81.58 ± 8.7) relative to the mild group (80.78 ± 9.2), with a T-value of 16.830 and a P-value of <0.0001. Similarly, hip circumference was larger in the moderate injury group (97.8 ± 12.8) compared to the mild group (95.007 ± 12.7), with a T-value of 36.942 and a P-value of <0.0001.

Interestingly, the Waist-to-Hip Ratio (WHR) was slightly lower in the moderate group (0.83 ± 0.05) than in the mild group (0.84 ± 0.05), yet this difference was statistically significant (T-value: 36.689, P < 0.0001). Conversely, no significant differences were observed in abdominal circumference (71.93 ± 9.6 vs. 73.62 ± 9.5; T-value: 1.012, P = 0.3220) or thigh circumference (45.83 ± 13.8 vs. 50.54 ± 21.1; T-value: 0.5490, P = 0.5883). These findings highlight that BMI, waist circumference, hip circumference, and WHR are significantly associated with the severity of musculoskeletal injuries, while abdominal and thigh circumferences show no significant association.

Table no. 2Correlation between Anthropometric measures and musculoskeletal injury in Bharatnatyam dancers

Outcomes	Correlation coefficient (r)	95% Confidence interval	Coefficient of determination (r squared)	P value
BMI	-0.5647	0.7885 To 0.2087	0.3188	0.0040
Waist circumference	-0.01967	0.4198 To 0.3869	0.0003867	0.9273
Hip circumference	0.2053	0.5622 To 0.2161	0.04216	0.3358
WHR	0.07780	0.3362 To 0.4666	0.006053	0.7178
Abdominal Circumference	-0.1604	0.5296 To 0.2599	0.02573	0.4540
Thigh Circumference	-0. 2059	0.5627 To 0.2154	0.04241	0.3343

The correlation analysis between anthropometric measures and musculoskeletal injuries in Bharatanatyam dancers is summarized as follows: BMI showed a moderate negative correlation with musculoskeletal injuries, with a correlation coefficient (r) of -0.5647, indicating that as BMI decreases, injury severity might increase. This relationship was statistically significant (P = 0.0040), with a coefficient of determination (r^2) of 0.3188, explaining 31.88% of the variability in injury outcomes.

Other anthropometric measures, including waist circumference (r = -0.01967, P = 0.9273), hip circumference (r = 0.2053, P = 0.3358), WHR (r = 0.07780, P = 0.7178), abdominal circumference (r = -0.1604, P = 0.4540), and thigh circumference (r = -0.2059, P = 0.3343), showed weak and statistically insignificant correlations with injury outcomes. The coefficients of determination for these variables ranged from 0.0003867 to 0.04241, indicating minimal explanatory power for the variability in musculoskeletal injuries.

These results suggest that BMI is the most meaningful anthropometric measure associated with musculoskeletal injuries in Bharatanatyam dancers, while other measures demonstrate negligible or no significant correlation.

Table no. 3 The BDIPQ score-wise distribution of musculoskeletal injuries in Bharatanatyam dancers

Bharatnatyam Dancers	Frequency	Percentage
Minimum	7	7.2
Mild	65	67.7
Moderate	24	25
Severe	0	0
Total	96	100%

Out of 96 dancers, the majority fell into the **mild category** (n = 65, 67.7%), indicating a relatively low severity of musculoskeletal injuries. A smaller proportion was classified under the **moderate category** (n = 24, 25%), reflecting a slightly higher but still moderate level of injury severity. Only a minimal number of dancers were categorized as having **minimum injuries** (n = 7, 7.2%), indicating near absence or very mild symptoms. Notably, no dancers (0%) were classified in the **severe injury** category.

This distribution highlights that musculoskeletal injuries in Bharatanatyam dancers are predominantly mild, with very few experiencing moderate or minimal injuries, and none facing severe injuries. This trend suggests that while injuries are common, their severity is generally manageable within this population.

DISCUSSION

This study explored the association between anthropometric measures and musculoskeletal injuries in Bharatanatyam dancers, shedding light on the prevalence, severity, and potential predictors of these injuries. The findings underscore the importance of addressing specific anthropometric factors and injury prevention strategies to support the physical well-being of dancers.

Prevalence and Severity of Injuries

The study revealed that 67.7% of Bharatanatyam dancers experienced mild injuries, 25% had moderate injuries, and 7.2% reported minimal injuries. Notably, no severe injuries were observed. These results align with earlier studies indicating that while Bharatanatyam is physically demanding, its emphasis on proper technique and structured practice may reduce the risk of severe injuries (Kumar LP et al., 2021). [10] However, the significant proportion of mild and moderate injuries highlights the need for targeted interventions to prevent these common issues.

Anthropometric Measures and Injury Correlation

Among the anthropometric measures assessed, BMI showed a significant negative correlation with musculoskeletal injury severity ($r = -0.5647$, $P = 0.0040$), suggesting that dancers with lower BMI might be more susceptible to moderate injuries. This finding supports prior research, which has linked lower BMI to decreased muscle mass and reduced joint stability, potentially heightening the risk of overuse injuries in repetitive activities like Bharatanatyam (Acharya S et al., 2024). [11] Other measures, such as waist circumference, hip circumference, and WHR, did not show significant correlations, indicating their limited influence in predicting injury severity in this population.

Implications for Practice

The results highlight the critical role of maintaining an optimal BMI and enhancing muscle strength to mitigate injury risks. Conditioning programs focusing on core stability, flexibility, and lower-limb strength could be particularly beneficial for Bharatanatyam dancers. Additionally, regular physiotherapy screenings and corrective measures for technique-related errors can play a pivotal role in injury prevention. Proper footwear, surface adjustments, and recovery protocols are also essential to minimize overuse injuries commonly seen in traditional dance forms (Rickman AM et al., 2012). [12]

Limitations and Future Directions

This study has several limitations. The cross-sectional design precludes establishing causality, and the reliance on self-reported injury data may introduce recall bias. Future longitudinal studies could provide a clearer picture of injury progression and its association with anthropometric measures over time. Moreover, integrating biomechanical assessments and analyzing kinetic and kinematic factors could offer deeper insights into injury mechanisms. Studies involving larger, more diverse samples of dancers from different regions and training regimens would also enhance generalizability.

CONCLUSION

This study highlights that musculoskeletal injuries in Bharatanatyam dancers are predominantly mild, with BMI emerging as a significant predictor of injury severity. By implementing targeted conditioning and injury prevention strategies, dancers can enhance their performance longevity and reduce injury risks. Continued research in this area is crucial to ensure the sustainability and health of practitioners in this intricate art form.

Declaration by Authors
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