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Morphometric analysis of ankle and foot in bharatanatyam dancers: A systematic review

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Abstract
Background: Bharatanatyam dancers excessively use lower limb for vigorous foot tapping and different postures which put them on the high risk of ankle and foot injuries. By understanding epidemiology and injury pattern of lower extremity, the prevention and treatment strategies for this population can be developed.
Methods: article systematically reviews epidemiological studies on Bharatanatyam injuries from 2010 to 2020 in which ankle and foot injury are included. 50 articles were selected for the review,10 duplicate articles were excluded, In the second stage, 12 articles were excluded After assessing the 28 full-text articles,6 studies that accomplished ≤9 points according to the STROBE checklist were excluded Finally, 12 studies were included in the qualitative synthesis.
Result: studies included showed injuries in ankle, foot in Bharatanatyam dancers. Out of which pes planus that is flat foot (2.4%) and Functional ankle instability (7.67%) was the most common injury reported. Stress fractures and ligament injuries were second most common injuries.
Conclusion: Based on the analysis prevalence of ankle and foot injuries in Bharatanatyam dancers is 15%. Common injuries identified in ankle and foot region are ankle sprain, peroneal tendonitis, Tendo Achilles tightness, flat foot, stress fractures and plantar fasciitis.

Keywords: Bharatanatyam, Kathak, foot deviation, Ankle injuries

Introduction
Bharatanatyam: Bharatanatyam is an Indian classical dance form that is practiced globally [3]. It is the most popular of the Indian classical dance form in south India and the most ancient among all the classical dance forms [4]. It is an ancient Indian classical dance form, originated in Tamil Nadu, a region of southern India [2]. Bharatanatyam has traditionally been a form of an explanatory narration of mythical legends and spiritual ideas from Hindu texts.
Emotion, rhythm, expression, and sculpturesque poses where a dance performance requires high demand of physical and psychological power during a performance [2]. There are many benefits of Bharatnatyam such as Improves flexibility Increases stamina Improves balance Provides healthy heart Improves concentration. Foundation of this dance form consists of basic steps along with rhythmic stamping of the feet and a multitude of crisp and meaningful hand gestures [3].
Bharatnatyam uses dancer's lower extremity. The most acquired posture in Bharatnatyam are Samapadam, Araimandi, Muzhumandi [5]. The greater cause of lower extremity turnouts Is AraimandI posture, where the dancer squats halfway and the heels are joined together along with the toes pointed out side. It is the basic posture acquired in Bharatnatyam where the knees are in closed chain position which. Tatta Adavu is a very important element In Bharatnatyam that includes foot ad ankle movements. Tatta literally means "to tap". In this Adavu, in Bharatanatyam it is the way of leg tapping [3]. Ankle bells known as ghungroos adds to the stress experienced in ankles. Daily use of the ankle bells can lead to tendon strain or can lead to over extension [6]. They practice repetitive movements that require extreme flexibility, strength, and endurance which increase the stress on their bodies and make them prime candidates for injuries because of overuse which may have an effect on their future health. Bharatnatyam dancers are more prone to ankle injuries and foot changes which can lead to flattening of the arch cause's postural instability and can affect balance [6]. Early identification of the injuries and changes can help in avoiding the bigger problems hance it is necessary to analyse ankle and foot problems in bharatnatyam dancers.

Methodology

Eligibility Criteria

Full text articles, Cross sectional study and observational study, Articles which are referred from past 10 years

Exclusion criteria

Duplicate articles, Systematic review, Articles with only abstracts.

Study Selection

Total 50 articles were selected for the review. Out of which 40 articles were identified as relevant as 9 duplicate articles were excluded. In the second stage 11 articles were excluded because of the inadequate statistical evaluation. After assessing the 27 full text articles, according to the eligibility criteria 9 articles were excluded. Finally, 17 were selected for methodological quality assessment. 6 studies that accomplished ≤7 points according to the Strobe checklist were excluded after the methodological quality assessment. Finally, 11 studies were included in the qualitative synthesis.

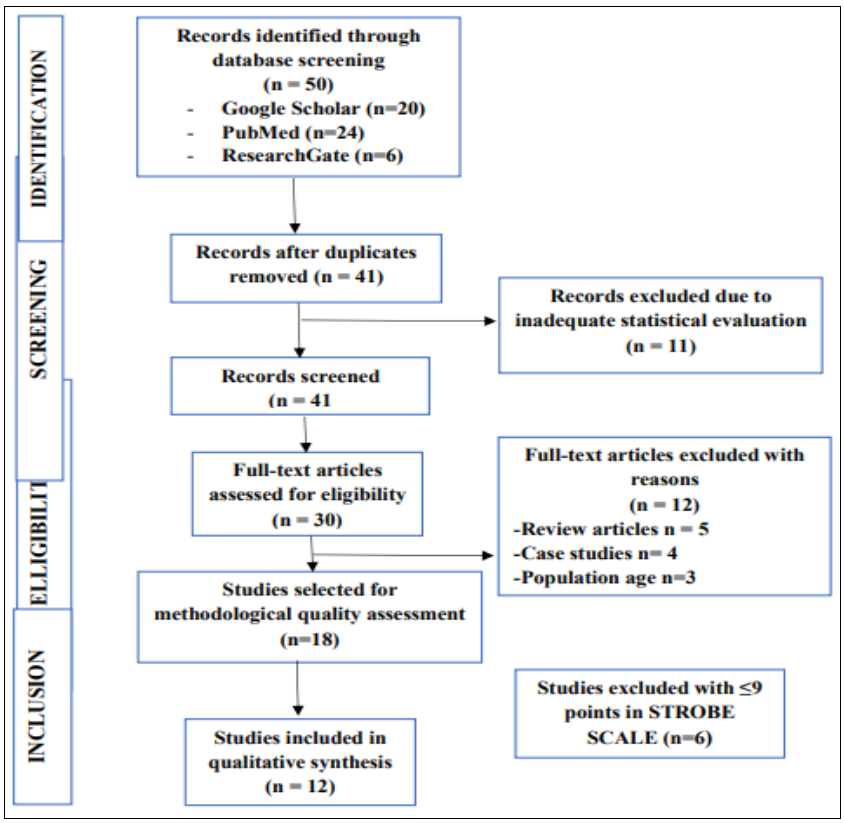

Fig 1: Flow chart of article selection according to Prisma

Results

Table 1: list of injuries in lower extremity according to the data synthesized

Knee (47.7*	Patellar femoral syndrome
	Anterior cruciate ligament injuries
	Medial tibial stress syndrome
Ankle (11.4%	Functional ankle instability (widening of the ankle mortise) (7.67%)
	Tendoachilles tightness
	Personal tendonitis
	Ankle sprains
Foot 116%) -	Pes planus (fiat foot) (2.4%)
	Metatarsal fracture
	Plantar fasciitis
	Microtrauma of soft tissues. Joint and ligaments

Discussion

The Indian classical dance form varies from state to state among which Bharatanatyam and kathak are popular forms practiced around India and across the globe [7]. According to the study, the majority of the body complaint that was found among Bharatanatyam dancers was the Low back pain (24%), knee (47.7%), Ankle (11.4%), Foot (2.4%) Shoulder and neck (7.5), and shin (2.6) [10].

In a recent study where the non-dancer's feet were compared with Kathak and Bharatanatyam dancers, it concluded that the difference between foot posture index in Kathak and Bharatanatyam dancers was not highly significant but the classical dancers showed foot pronation that is flattening of a medial arch more than the non-dancer [7]. It was stated that the impact forces generated due to constant tapping of the foot on hard surfaces place stress on the joints of the foot, the high loading on the foot is because of the 4-5 times more ground reaction force that is experienced by the foot [10, 11]. Taps are vigorously performed constantly at varying speeds for a minimum of an hour. The lower extremities suffer injury because of the amount of force passing through them [3]. According to the studies, 70% of dancers had flat-arched foot 20% of dancers had a high arched foot. Some studies concluded that along with flat foot dancers had muscle tightness [3].

Most of the dancers started their practice at a very young age and most of the problems occur over a period of time which interferes with the growth and development of arches of the foot [3]. The factors responsible for injuries are stress and overwork tiredness, falls, inadequate exercise, and hard flooring. The dancers learning Bharatanatyam have more pain in foot and ankle because of constant foot tapping [3, 7, 8, 9, 11, 13]. Another factor contributing to the flattening of the foot Is overuse of the invertors of the foot as it requires strong

contractions to have controlled motion at the foot on the Hard floor [9]. In reduced medial arch the ankle rolls medial adding to the load on the medial aspect of the foot [7].

The talus lies at a preeminent position in the medial longitudinal arch which bears the whole weight of the body. The flattening of the medial arch leads to disturbance in the alignment of the talus. This may disturb the other tarsal bones. Which may directly cause injuries [13]. The exertion on the foot causes muscles to get fatigued which causes stress on the bones, which leads to strain at the site of the origin of the muscles giving rise to conditions such as periostitis and tendonitis [13]. Because of continuous wearing of ghungroos, the friction between the skin and the ghungroos causes excessive blisters. Extra stress on the foot and ankle musculature contribute to the development of peroneal tendonitis, and metatarsal and fibular stress fracture.

Studies suggested that 70% of the dancers had ankle instability [13]. Because of the dance form the ankle is in complete dorsiflexion and plantarflexion which causes the ligaments to undergo maximum tensile loading. The position causes the talus to press against the lateral malleolus which causes stress on the ankle mortise thus causing ankle instability [13]. According to the studies ankle sprains are the most common in ballet dancers which is caused because of the positions of the foot [15].

The study also stated that the practice of Bharatanatyam has shifted from mud flooring to non-resilient surface that is granite and concrete. The dancer has to tap harder on the floor to create a foot slap sound which adds to the raga component. [9] The contributing factors to the injury are the force and the velocity generated and also the area of contact between the foot and the surface. The impact force during TATTA ADAVU was higher on granite forces when compared to polyvinyl surfaces and wooden surfaces. When the dancer is on a less resilient surface the comfort level is higher [9].

The main contributor of injuries in dancers is the constant requirement of the legs to absorb the landing forces by eccentrically contracting the muscles. Dancers develop injuries over a period of time. Lack of stretches and muscle tightness can lead to wear and tear changes in the weight bearing joints, if appropriate warm up and stretching exercises before and after a dancing session are not performed, dancers develop various balance and overuse Injuries because of the progressive microtrauma and degenerative changes. Improvements in the attentional network have been linked to traditional art. This appears to be a significant benefit that increases endogenous level preparing for uncertain aims. Because the ability to assign attention is so important in any type of art, it's fair to assume that dancers improve their ability to modulate attention. Skilled dancers that require rapid changes in visual input, may be able to improve their ability to modulate attention to concentrate their attention more effectively than others who do not participate in similar activities [15].

After that analysis of articles, it was concluded that regular practice of the dancers on the hard flooring for many hours causes injuries in the ankle and foot. The regular assessment will help in reducing the injuries in the dancers. According to the data synthesized it is suggested to practice on the non-resilient floors to avoid the foot changes.

Table 2: Shows in Journal name and location

SR. NO	TITLE	NAME OF JOURNAL	YEAR OF PUBLICATION	SAMPLE SIZE/GENDER	Location	OUTCOME MEASURE	RESULT& CONCLUSION
1	A comparative study of foot posture deviation in young female kathak and Bharatnatyam dancers	INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH	Oct-20	44 Kathak Dancers, 44 Bharatnatyam Dancers and 44 Non-Dancers	K. J. Somaiya College Of Physiotherapy Sion, Mumbai	Foot Posture Index – 6 scale– Non Parametric ANOVATest.	There was no significant difference in foot of Kathak and Bharatnatyam Dancers. Except the non-dancers
2	Vertical ground reaction force while performing an Indian classical dance Bharatnatyam	International Journal of Orthopaedics and Physiotherapy	Dec-20	Five subjects (three females and two males)	Ortho One Orthopaedic Specialty Centre, Chennai, Tamil Nadu, India	ANOVA	A non-resilient surface and an elastic surface both produce higher impact forces Hence, selecting an ideal surface for dance is imperative to avoid injuries.
3	Ground reaction forces during variations of bharatanatyam	h International Society of Biomechanics in Sport Conference	Jul-19	Seven experienced dancers volunteered for the study	Centre for sports science medicine Manipal	Gen5 Optima amplifier Netforce software single force platform	This study revealed that during the foot tapping 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.
4	Foot postural deviation in female kathak dancers	International journal of physiotherapy and research	Feb-17	40 Female Kathak Dancers	Punjabi university Patiala	Foot posture index Navicular drop test Forefoot angle Medial longitudinal arch	It can be concluded that the kathak dancers start developing hyper pronation in foot. These changes if not treated on time may lead to various degenerative changes in the Foot & ankle
5	Analysis of Lower Extremity Muscle Flexibility among Indian Classical Bharathnatyam Dancers	International Journal of Medical, Health, Biomedical, Bioengineering and Pharmaceutical Engineering	2012	401 female dancers (177 Normal, 224 – Injured) and 17 male dancer (13 – Injured, 4 – Normal	Ortho one Orthopaedic Speciality centre Coimbatore	Goniometer Instrument	Observation results show that a flat foot complaint was high for injured dancers as compared to normal. Iliocibial Band(ITB) muscle tightness was high and
6	Kinematics and kinetics assessment of lower limb movements in Bharatnatyam dancers		2019	6 young adults (3 dancers and 3 non-dancers	University of Malaya Kualalumpur	Beam scale Anthropometer Tape measure	Results show that wearing dancing bells have impact dancers ground reaction force by producing high vertical ground reaction peak at maximum loading response
7	Analysis of foot load during ballet dancers' gait	Acta of Bioengineering and Biomechanics	Sep-13	13 Dancers (5 men and 8 women.)	Palacky university Olomouc Czech Republic	2 m pressure plate	From this non physiological foot usage, a variety of pathologies can originate, e.g. ankle sprain, stress fractures, deformities

Table 3: Score of articles on the basis of strobe scale

SR NO	Study title	Location	Study Design	STROBE Score
1	A comparative study of foot posture deviation in young female kathak and Bharatanatyam dancer	K. J. Somaiya College Of Physiotherapy Sion, Mumbai	comparative study	10
2	Cross-Sectional Study of Foot Posture Index, Navicular Drop and Arch Index in Kathak Dancers	Banarsidas Chandiwala Institute of Physiotherapy, New Delhi	Cross-Sectional study	12
3	Vertical ground reaction force while performing an Indian classical dance Bharatanatyam.	Ortho One Orthopaedic Specialty Centre, Chennai, Tamil Nadu, India	Biomechanical study	11
4	Foot postural deviation in Female kathak dancers	Punjabi university Patiala	Cross-Sectional study	12
5	Balance in Bharatanatyam dancers and non-dancers	D. E. Society's Brijlal Jindal College of Physiotherapy Pune	Comparative study	15
6	Analysis of Lower Extremity Muscle Flexibility among Indian Classical Bharathnatyam Dancer	Ortho one Orthopaedic Speciality centre Coimbatore	Observational and Comparative study	14
7	Evaluation of Foot Posture, Pain and Ankle Proprioception in Classical and Western Dancers	KLE institute of physiotherapy Belgavi, Karnataka	Cross - sectional study	16
8	Prevalence of ankle instabilities and disabilities among female Kathak dancers	Department of physiotherapy Punjabi university Patiala	Observational study	16.5
9	Survey of Musculoskeletal Disorders Among Indian Dancers in Mumbai and Mangalore	MGM Institute's university department of physiotherapy Navi Mumbai	Observational study	15.5
10	kinematics and kinetics assessment of lower limb movements in bharatanatyam dancer	University of Malaya Kualalumpur	Cohort study	15.5
11	Ground reaction forces during tatta adavu of bharatanatyam	Centre for sports science medicine Manipal	Comparitive study	12.5
12	Analysis of foot loading during ballet dancers's Gait	Palacky university Olomouc Czech Republic	Observational study	16.5

Conclusions

Based on the analysis prevalence of ankle and foot injuries in Bharatanatyam dancers are been 15%. Common injuries identified in ankle and foot region are ankle sprain, peroneal tendonitis, Tendo Achilles tightness, flat foot, stress fractures and plantar fasciitis. These injuries show association with intrinsic risk factors like BMI, Age and extrinsic factors like type of flooring, practice hours and ghungroos.

Clinical implication

As per the study the Bharatanatyam dancers have high risk of flat foot that is pronated foot and ankle sprains and stress fractures. If the epidemiology of injuries are early identified, it may help in reducing the risk on injuries and to have proper coping strategies

Conflict of interest

There was no conflict of interest

Limitation of study

The study was time bound

Study demographics

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