

Association of Foot Deviations with Foot Functional Activity and Dynamic Balance in Female Kathak Dancers

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ABSTRACT

Kathak, an Indian Classical dance involves complex rhythmical foot work which makes Kathak dancers more prone to foot posture deviations and musculoskeletal injuries. Foot deviations can be associated with ankle and foot pain, joint and postural instability, soft tissue injuries, etc. which may negatively affect balance and dance performance. Hence current study aimed to explore association of foot deviation with foot functional activity and dynamic balance among female Kathak dancers. A cross-sectional study design 80 female Kathak dancers between age group of 18- 40 years were assessed for foot deviations, foot functional activity, and dynamic balance by Navicular drop test, foot function index, and Y balance test respectively. Percentile analysis of Navicular drop test showed that a large population of Kathak dancers (56.25%) has pronated feet. Foot functional activity showed that maximum population (86.25%) didn't have any foot function impairment. 25% population had below baseline score in Y balance test showing higher risk of losing balance and musculoskeletal injuries. Pearson's correlation showed that Navicular drop test has very weak positive correlation with Foot Function Index with R value 0.21 and has a very weak negative correlation with Y balance test with R value -0.027 and -0.03 of right & left leg respectively. Thus, current study concludes that Kathak dancers are more prone to have flat feet. Medial Longitudinal Arch Height has very weak positive correlation with foot function and very weak negative correlation with Y balance test suggesting that flat feet have very weak impact on foot function and dynamic balance.

Keywords: Kathak dancers, Medial longitudinal arch height, Navicular drop test, Dynamic balance, Foot function index.

INTRODUCTION

Kathak is a classical dance form originated from Uttar Pradesh, North India. This energetic and storytelling dance involves *nritta* (pure dance), *nriya* (expressive dance) and *natya*. It is mainly based on hand mudras, facial expressions and complex

footwork comprising of fast twists, quick and rhythmical foot movements.

Footwork called "Tatkar" is the base of Kathak performed in various tempos. The "V Stance" practiced by Kathak dancers necessitates keeping an extremely turned-out foot stance, resulting in the forefoot to

be turned outward further than the foot axis. This places a significant amount of tension on the inner sides of the foot, leading to functional hyperpronated foot also known as functional flat foot.^[1] Dancers even adopt these bad foot postures elsewhere besides the dance practice, which may have an impact on their foot functional activity.

Kathak dancers utilize ghungroos (dancing bells) while performing spinning moves (chakkars) which provides rhythm to their performance.^[1] Each dancing bell comprises of 100-150 ghungroos weighing approximately 1-1.5 kgs which varies according to years of practice and skill. They add more tension on foot while lifting the feet and can lead to agonist and antagonist muscle imbalance. Daily use of these ankle bells for years may overload the connective tissues of legs and can lead to overextension, tendon strain during the performance.^[1]

Practice of complex foot work with ghungroos for prolonged hours might overload the foot and exposes lower limb to great amount of stress abundant enough to make foot prone to significant biomechanical changes. Given that the medial longitudinal arch is durable, repeated pounding on hard floor causes it to permanently depress. Flat feet is the term for an excessively low medial longitudinal arched foot, which has been linked to abnormal tibialis posterior tendon sheath functions, including pain, damage to the joint, dynamic imbalance, and even stress fractures.^[2]

The nature of dancer's feet causes the ankle to be forced into extreme plantar flexion. Hence, the kathak dancer is repetitively placing the ankle in an unstable position. The demands placed on dancer's lower extremity makes them more vulnerable to various musculoskeletal injuries. In professional dancers, incidence of foot and ankle injuries is 23%-45% out of all reported injuries. The foot and ankle of a dancer are particularly vulnerable to injury and represents 34% to 62% of all injuries reported. Primary and secondary kinetic

chain dysfunctions are common in dancers.^[3]

The extreme strains that Kathak dancers undergo due to prolonged practice may have an impact on their performance and can lead to problems like heel pain, tenderness, trigger points, postural instability affecting their daily functional activity.^[4] The lower extremity chain bears responsibility for critical daily functions, the most essential being weight bearing and ambulation.^[5] The foot and ankle provides a base of support that aids in postural stability and flexibility during various ADLs and dance performance. The foot is essential for maintaining balance and any change to the medial longitudinal arch may result in abnormalities in the maintenance of balance.^[4]

Many studies have been performed on dancers of different western dance forms and athletes. But till date limited literature is available in relation to Kathak dance form even though it has been practiced since ages in India. In order to prevent injuries and to scale down its complications, it is necessary to have a detailed understanding of relationship of foot deviation with foot function and balance. Hence current study aimed to assess foot functional activity, foot deviations, dynamic balance and foot pain in female Kathak dancers.

Foot functional activity can be assessed by Foot Function Index (FFI), developed in 1991 to measure the impact of foot pathology on function in terms of pain, disability, and activity restriction. It is a self-administered index of 23 items divided into 3 sub-scales. Both total and sub-scale scores are produced.^[6] Any deviation in the foot posture of kathak dancers from neutral can be assessed by Medial longitudinal arch height, which is crucial for examining individuals with overuse problems. Navicular Drop Test (NDT) is a method for assessing the medial longitudinal arch's height and classifying foot into neutral, supinated and pronated foot type.^[7] Y Balance Test (YBT) is a reliable and comprehensive measure to assess dynamic

balance in healthy asymptomatic adults. This portable and inexpensive tool evaluates single leg balance, dynamic neuromuscular control, proprioception and strength while an individual reaches with the non-stance limb in three directions.^[8]

MATERIALS & METHODS

In this cross-sectional study design, 80 female Kathak dancers within age group of 18-40 years were selected by purposive sampling technique from various Kathak Dance Academy in and around PCMC, Pune. Female Kathak dancers within age group of 18-40 years who had 2 or more than 2 years of dance practice, normal BMI (18.5-24.9 Kg/m²), and who were willing to participate in the study were included in the study. Subject who had any ankle or knee joint instability or injury in past 1 year, surgery of lower limb, spine and abdomen in last 3 months, and subjects with neurological dysfunction, musculoskeletal dysfunction, psychiatric conditions were excluded from the study.

PROCEDURE

After obtaining ethical approval from the Institutional Ethics Committee, 80 female Kathak dancers were selected according to the inclusion and exclusion criteria. The aim and method of the study was explained and informed written consent was taken from all participants. All the participants were assessed for medial longitudinal arch height,

foot functional activity and dynamic balance by NDT, FFI & YBT respectively.

Foot function index:

The foot function index consisting of 23 self-reported items is divided into 3 subcategories on the basis of patient values: pain, disability, and activity limitation. The individual scored each question on a scale from 0 (no pain or difficulty) to 10 (worst pain imaginable or so difficult it requires help), which best described their foot over the past week. Both total and subcategory scores were calculated.^[6]

Navicular drop test:

NDT was used to measure Medial Longitudinal Arch Height. Individual subject was placed in a sitting position with their feet flat on a firm surface with the hip and knees flexed to 90 degree and ankle joints in neutral position. Subtalar neutral position was achieved when talar depressions were equal on medial and lateral side of the ankle. The examiner took measurement by kneeling in front of the subject. While the subject was still in a sitting position, a dot was marked on the navicular tuberosity. An index card was placed and was marked at the level of navicular tuberosity. Then the subject was asked to bear an equal weight on both the foot and was asked to stand. The new position of navicular tuberosity was marked on index card. The difference was noted in the units of millimetre. Both right and left feet were assessed.^[7]



Figure 1. Navicular Drop Test Start and End Position

Y balance test:

YBT was a simple yet reliable technique for measuring dynamic balance. The individual was made to balance on one leg while reaching as far as possible with the other leg in toe touch with 3 trials in three different directions: anterior, posterolateral, and posteromedial. The individual was also informed not to keep their leg down during the trial as it may lead to start the test again.^[8]



Figure 2. Y Balance Test

STATISTICAL ANALYSIS

Statistical analysis was done by Statistical Package for the Social Sciences (SPSS) software version 23. Descriptive statistics and percentile analysis was used to assess quantitative measurements. Pearson’s correlation was used to analyze association of Medial Longitudinal Arch Height with Foot Function and Dynamic Balance with confidence interval 95% and the p value >0.05.

RESULT

Table 1. Mean and SD of Variables

Sr. No.	Outcome Measures	Mean	+/-SD
1.	Age	25.55	+/-8.322
2.	BMI	22.65	+/-2.25
3.	Foot Function Index	20.056	+/-10.154
4.	Navicular Drop Test (Right)	10.562	+/-1.088
5.	Navicular Drop Test (Left)	10.562	+/-1.088
6.	Y Balance Test (Right)	89.5	+/-6.582
7.	Y Balance Test (Left)	89.8	+/-6.836

Table 1 represents mean and standard deviation of quantitative measurements - age, BMI, Foot Function Index, Navicular drop test and Y balance test for right and left.

Table 2. Age Distribution of Study Population

	AGE				
Years	18-22	23-26	27-30	31-35	36-40
Participants	48	08	01	06	17
Percentage	56.7%	26.9%	1.5%	4.5%	10.4%

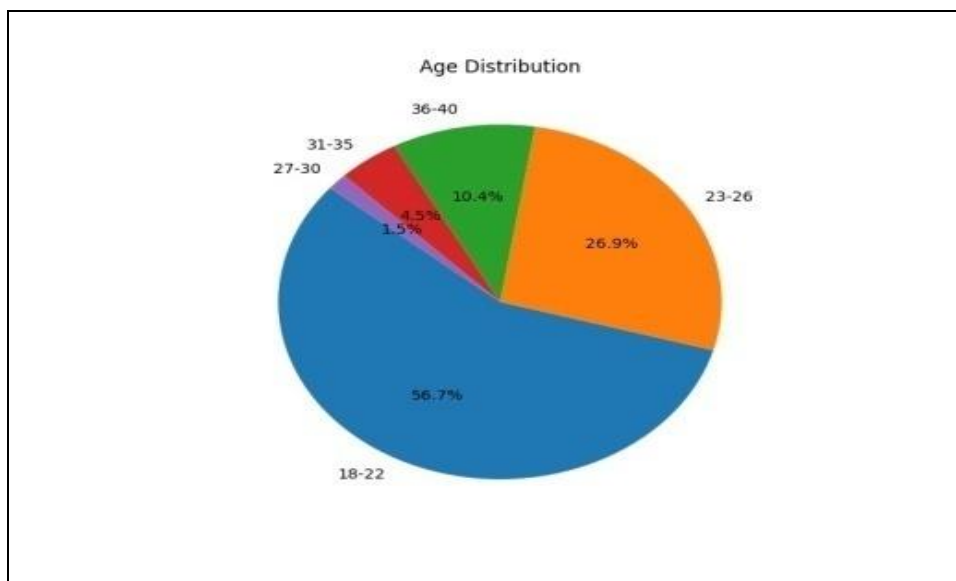


Figure 3. Age Distribution of Study Population

Table 2 and Figure 3 represents age wise distribution among study population which showed that maximum population belonging to age group 18-22 years with 48

participants is 56.7% and minimum population belonging to age group 27-30 years with 1 participant is 1.5%.

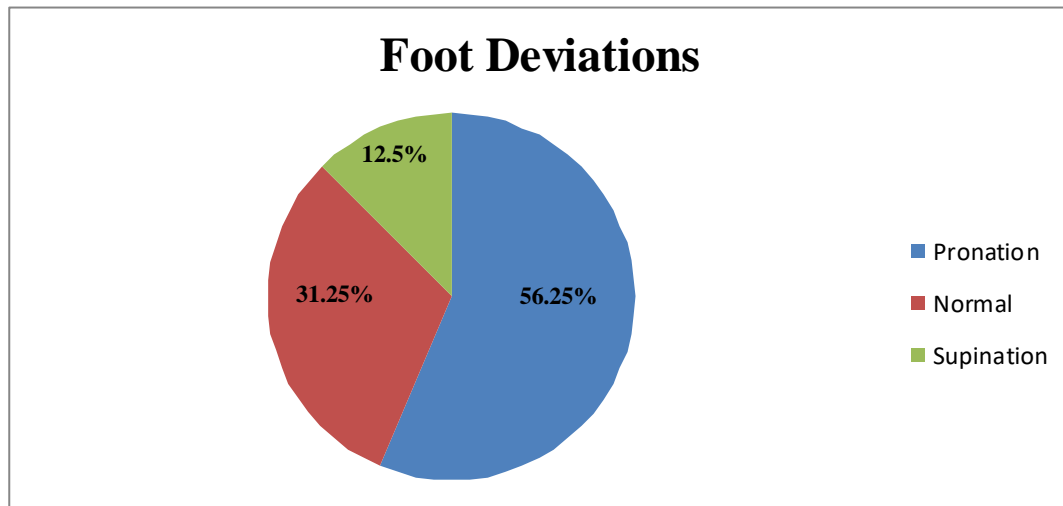


Figure 4. Foot Deviations in Study Population

Figure 4 represents foot deviations among study population which showed that a maximum population that is 45 dancers had pronated feet (56.25%), 25 dancers had

normal foot type (31.25%) and minimum population - 10 dancers had supinated feet (12.5%).

Table 3. Representation of Foot Functional Activity among Different Foot Types

Foot Function Index	Total No. of participants	No impairment <25	Mild impairment 25 – 30	Moderate impairment 50 - 75	Severe impairment >75
No. of participants	80	69	8	3	0
Normal Foot type	25	24	1	0	0
Pronated Foot type	45	37	5	3	0
Supinated Foot type	10	9	1	0	0

Table 3 represents foot functional activity among study population which showed that most of the population (86.25%) did not have any pain, disability and activity limitation leading to any foot function impairment, whereas 1% population had mild impairment and 3.75% had moderate

impairment. 4% population among normal foot type had mild impairment, among pronated foot type 11% population had mild impairment and 3.75% population moderate impairment and 10% population among supinated foot type had mild impairment.

Table 4. Representation of Dynamic Balance among Different Foot Types for Right & Left Leg

Y Balance Test	Total No. of participants	Risk of injury <89%		Baseline 89% - 94%		No risk >94%	
		RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT
No. of participants	80	20		27		33	
Normal Foot Type	25	4	3	11	10	11	11
Pronated Foot Type	45	17	15	11	15	16	16
Supinated Foot Type	10	1	2	3	3	6	5

Table 4 represents Dynamic balance among different foot types for right and left leg stating that maximum study population

41.25% had good score in YBT and having no risk of losing balance and injuries. 33.75% population had baseline score in

YBT and 25% population had below baseline score showing that they are more prone to losing balance and musculoskeletal injuries. 12% population with normal foot type, 35.55% with pronated foot type and

10% with supinated foot type had below baseline score. People with pronated foot type showed higher risk of losing balance and musculoskeletal injuries.

Table 5. Pearson's Correlation

OUTCOME MEASURES	NAVICULAR DROP TEST (RIGHT) R VALUE	NAVICULAR DROP TEST (LEFT) R VALUE	P VALUE
FOOT FUNCTION INDEX	0.21	0.21	0.0562
Y BALANCE TEST	-0.027	-0.03	0.7939

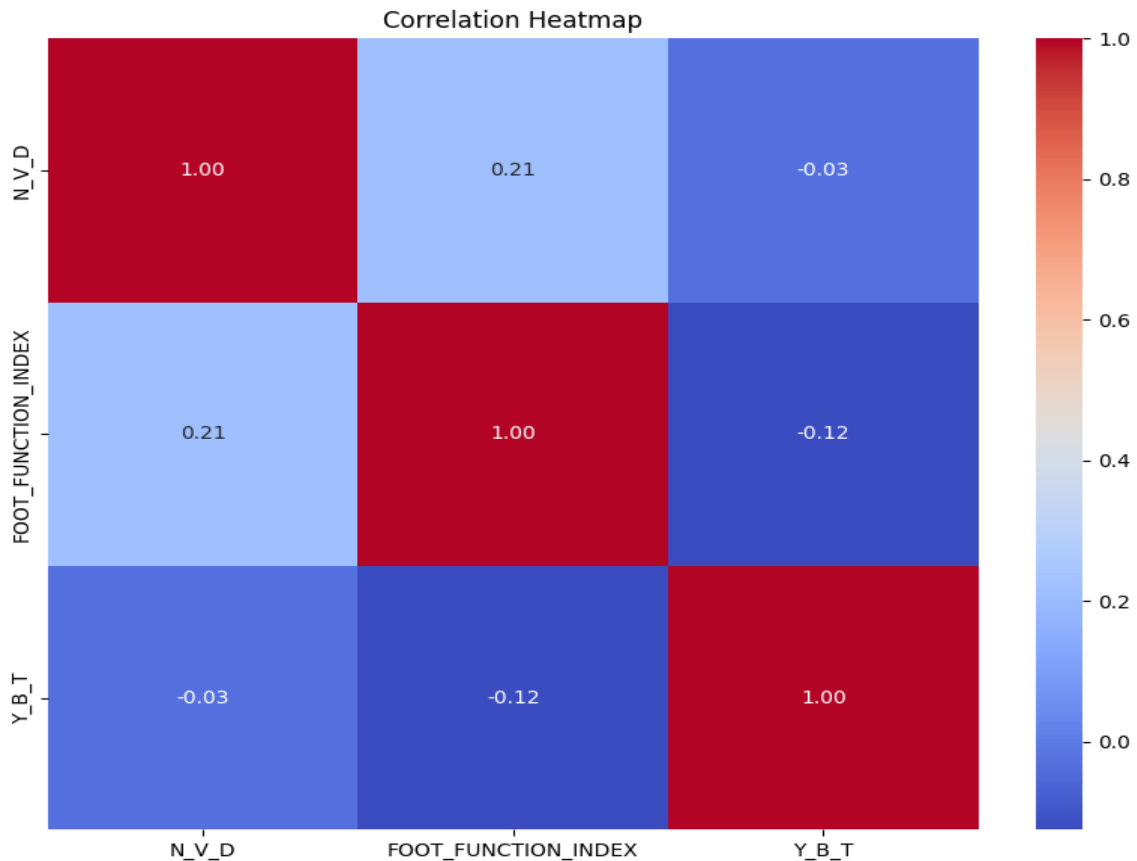


Figure 5. Correlation Heatmap of NDT with FFI & YBT

Table 5 and Figure 5 represent an association of NDT for right and left foot with FFI & YBT for right and left foot. Pearson Correlation showed that there is a positive correlation between NDT and FFI with Correlation coefficient values (R value) 0.21. This suggests that as Navicular Drop Test increases, there is a tendency for Foot Function Index to increase. The p-value of 0.0562 is slightly above the conventional significance level of 0.05 indicating that it is not statistically significant.

Results showed that there is a very weak negative correlation between NDT and YBT with correlation coefficient values (R value) -0.027 of right leg and -0.03 of left leg respectively. This suggests that there is no substantial linear relationship between NDT and YBT. The p-value of 0.7939 is well above 0.05 indicating no statistically significant correlation.

DISCUSSION

The objective of the study was to assess foot functional activity, medial longitudinal arch height, foot pain and dynamic balance and

to study the association of medial longitudinal arch height with foot functional activity and dynamic balance in female Kathak dancers. The study was conducted on 80 female Kathak dancers between the age of 18-40 years with mean age of the study population was 25.55 with SD +/- 8.322.

Assessment was done for Medial longitudinal arch height by NDT and foot function with FFI and dynamic balance by YBT. Zuñil-Escobar Jc et studied Medial Longitudinal Arch: Accuracy, Reliability, and Correlation Between Navicular Drop Test and Footprint Parameters Both intrarater and interrater reliability were excellent for all the parameters evaluated (intraclass correlation coefficients >0.880).^[4] According to Elly Budiman-Mak et studied a review of foot function and foot function index in which test-retest reliability of the FFI total and sub-scale scores ranged from 0.87 to 0.69 Internal consistency ranged from 0.96 to 0.73.^[5] Along with that Yousef Alshehre et studied Reliability and Validity of the Y-balance Test in Young Adults with Chronic Low Back Pain with excellent inter-rater reliability, with intraclass correlation coefficients ranging from 0.99 to 1.0.^[8]

In our study foot postural deviations in the Kathak dancers were assessed using Navicular drop test which showed alterations in the Medial Longitudinal Arch Height. Navicular drop test helps to assess height of medial longitudinal arch and to classify foot type as neutral, pronated, or supinated accordingly. In current study, out of 80 Kathak dancers, 45 dancers had flat feet (56.25%), 25 dancers had normal foot type (31.25%) and 10 dancers were with supinated feet (12.5%). Kathak dance form interferes with the growth and development of the foot's arches because the majority of dancers began their training at a very young age and most issues develop over time.^[2]

Kathak dancer's foot work with V stance may be the cause of their postural deviations toward pronation as they keep their feet pointed outward and in a pronated posture.

The foot gradually becomes more pronated with repetition, stabilizing or fixing itself in that posture. Over time, the dancers form a habit of keeping their feet in this abducted position even when they are not practicing. This leads the foot's position to be more pronated during both static and dynamic weight bearing.^[1] Kathak dancers need powerful contractions of foot's invertor muscles to have controlled motion at the foot on the hard floor.^[2] The medial arch is weakened by excessive tapping on hard floor and usage of the intrinsic muscles, which causes the foot to flatten and deviate toward a pronated position.^[1] Eustace et al. in 1994 suggested that height of the medial longitudinal arch outweighs all the other factors which can lead to metatarsal pronation.^[9]

Foot functional activity was assessed by foot function index which showed that most of the population (86%) did not have any pain, disability and activity limitation leading to any foot function impairment; whereas 1% population had mild impairment and 3.75% had moderate impairment. We explored the association between medial longitudinal arch height and foot function which showed that foot type has very weak positive correlation with Foot Function Index with Correlation coefficient values (R value) 0.21. The positive correlation suggests that a rise in Navicular Drop Test could be linked to a reduction in foot function, potentially resulting in limitations or impairments to foot performance and overall function. Based on research by Pavana et al. where they determined if foot deviations and related foot injuries have any impact on foot function where they found out that foot posture index was normal and didn't have restrictions on foot usage while dancing whereas with foot function index it was observed that pain experienced by dancers restricted their daily activities and hampered their dance performance.^[5]

In our study dynamic balance was assessed using Y balance test to check if foot type affects balance as Kathak dancers have

various types of footwork due to which instability can occur. Results stated that maximum study population (41.25%) had good score in YBT and having no risk of losing balance and injuries. 33.75% population had baseline score in YBT and 25% population had below baseline score showing that they are more prone to losing balance and at risk of musculoskeletal injuries. Further analysis revealed that Navicular Drop Test and Y Balance Test have a weak negative correlation with correlation coefficient values (R value) -0.027 of right leg and -0.03 of left leg. The negative correlation suggests that as NDT value increases showing flattening of medial arch, YBT score reduce showing more risk of losing balance and musculoskeletal injuries. But the impact is not significant as we can expect postural adaptations and muscular compensatory action of postural adaptation during the balance test. The tibialis anterior and peroneus longus muscles are important in compensating for and adapting to postural balance during dynamic motion, which can happen due to external factors such biomechanical considerations and visual integration, auditory, somatosensory, and other proprioceptive systems.^[10] Flattening of the medial arch might put more strain on the neuromuscular system in order to keep the foot stable and maintain an upright posture.^[11]

Other factors contributing to good YBT score could be young age, good foot functional status, complex dance formation and spins challenging their balance. When bearing weight, the medial longitudinal arch slightly descends and instantly rises back up. This contributes to the foot's increased surface area contact with the ground through pronation, hence strengthening its stability.^[1] Karen P. Cote et al found out that there was no significant relation in foot type and static balance but there was difficulty in reaching to a certain direction in dynamic balance testing like the supinated foot had a significant difference in the lateral direction.^[12] Hyouk Hyong, &

Jong Ho Kang, conducted a study to compare dynamic balance activities with foot shape related to the medial arch of the foot in which they found that there is no significant relationship between dynamic balance activities and foot shape related to the medial arch of foot among young individuals. The reason for being reduction in the dynamic balance ability adjustment is believed to be due to the relative lack of connectivity with the talocrural and subtalar articulations that are responsible for foot balance.^[10]

Hence we can conclude that Kathak dancers are more prone to have foot deviation such as flat feet and can have very weak impact on foot function and dynamic balance.

CONCLUSION

Kathak dancers are more prone to have foot deviation such as flat feet. Medial Longitudinal Arch Height has very weak positive correlation with foot function and very weak negative correlation with Y balance test suggesting that flat feet has very weak impact on foot function and dynamic balance.

Declaration by Authors

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REFERENCES

1. Roopika Sabharwal, Sonia Singh. Foot Postural Deviations in Female Kathak Dancers. *Int J Physiother.* 2017; 4(1):38-43. DOI: 10.15621/ijphy/2017/v4i1/136163
2. Jacqui Haas. *Dance Anatomy.* 2nd ed. United States of America: Human Kinetics. 2010; 145-168.
3. Shweta Chandan, Savita Tamaria, Davinder Gaur, et al. Cross-Sectional Study Of Foot Posture Index, Navicular Drop And Arch Index In Kathak Dancers. *International Journal of Research and Review.* 2018; 5(6):157-164.
4. Zuil-Escobar JC, Martínez-Cepa CB, Martín-Urrialde JA, et al. Medial

- longitudinal arch: accuracy, reliability, and correlation between navicular drop test and footprint parameters. *Journal of manipulative and physiological therapeutics*. 2018; 41(8):672-9. DOI: 10.1016/j.jmpt.2018.04.001.
5. Chanageri SV, Pruthviraj R. Assessment of Foot Deviations and Associated Foot Injuries and its Effect on Foot Functional Activity among Amateur Adolescent Female Kathak Dancers in Selected Dance Schools in Bengaluru. *Indian Journal of Physiotherapy & Occupational Therapy*. 2023; 17(3):54-59. DOI: <https://doi.org/10.37506/ijpot.v17i3.19550>
 6. Budiman-Mak E, Conrad KJ, Mazza J, Stuck RM. A review of the foot function index and the foot function index-revised. *Journal of foot and ankle research*. 2013; 6(1):5. DOI: 10.1186/1757-1146-6-5.
 7. Adhikari U, Arulsingh W, Pai G, Raj JO. Normative values of navicular drop test and the effect of demographic parameters-A cross sectional study. *Annals of Biological Research*. 2014; 5(7):40-8. DOI: <https://api.semanticscholar.org/CorpusID:56326743>
 8. Alshehre Y, Alkhatami K, Brizzolara K, Weber M, Wang-Price S. Reliability and validity of the Y-balance test in young adults with chronic low back pain. *International Journal of Sports Physical Therapy*. 2021; 16(3):628. DOI: <https://doi.org/10.26603/001c.23430>
 9. Eustace S., Byrne J.O., Beausang O., Codd M., Stack J., Stephens M.M. Hallux Valgus, First Metatarsal Pronation and collapse of the Medial Longitudinal Arch – a radiological correlation. *Skeletal Radiol*.1994; 23(3):191-194. DOI: 10.1007/BF00197458.
 10. Hyong IH, Kang JH. Comparison of dynamic balance ability in healthy university students according to foot shape. *Journal of physical therapy science*. 2016; 28(2):661-4. DOI: 10.1589/jpts.28.661
 11. Atamtürk D. Relationship of flatfoot and high arch with main anthropometric variables. *Acta orthopaedica et traumatologica turcica*. 2009; 43(3):254-9. DOI: 10.3944/AOTT.2009.254
 12. Cote KP, Brunet ME, Gansneder BM, Shultz SJ. Effects of Pronated and Supinated Foot Postures on Static and Dynamic Postural Stability. *J Athl Train*. 2005; 40(1):41-46.
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