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EFFECT OF PLYOMETRIC TRAINING ON DYNAMIC BALANCE AND FOOT PAIN IN BHARATNATYAM DANCERS

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1. ABSTRACT

Background: *Bharatnatyam is an Indian classical dance form originated in Tanjore, a small village of Tamilnadu. Dancers are exposed to substantial physical demands, particularly on the lower extremities, due to the complex and high-intensity nature of their movements. These movements require advanced dynamic balance, a key component of both performance and injury prevention. Plyometric training can benefit Bharatnatyam dancers by enhancing explosive power, improving agility and coordination and boosting neuromuscular efficiency, all of which are crucial for the dynamic movements, intrinsic footwork and quick transitions in dance forms.*

Method: *Thirty individual aged 15-25 years with Y-Balance Scale and Visual Analogue Scale scores were divided into two groups: Plyometric exercise group and Short Foot exercise group. Both interventions performed four times a weekly for six weeks.*

Results: *In Plyometric group Y-balance mean composite score ($t(14) = -3.92$, $p = .002$; $d = -0.62$ to -1.38), VAS ($t(14) = 14.47$; $p < .001$; $d = 3.74$) . In Short foot group significant improvement in selected YBT variables only, namely left posteromedial reach ($t(14) = -3.87$, $p = .002$), left composite score ($t(14) = -3.23$, $p = .006$), and mean posteromedial reach ($t(14) = -3.01$, $p = .009$), VAS ($t(14) = 8.34$, $p < .001$, $d = 2.15$).*

Conclusion: *These findings indicate that both interventions were effective in reducing foot pain, but plyometric training was more effective than short foot exercises in improving dynamic balance and achieving greater pain reduction in Bharatnatyam dancers.*

KEYWORDS: *Bharatnatyam dancers, Dynamic balance and foot pain, Y-balance scale, Plyometric exercise, Short foot exercise*

2. INTRODUCTION

Bharatanatyam is a traditional Indian classical dance form originating from Tamil Nadu, known for its grace, rhythmic footwork, and expressive movements. It involves a combination of postures, foot stamping, jumps, and turns that demand high levels of physical strength, flexibility, endurance, and neuromuscular control. [2] Due to prolonged practice sessions and repetitive performance of complex movements, dancers are frequently exposed to significant physical stress.[8]

The repetitive nature of Bharatanatyam movements, especially foot stamping, jumps, and sustained postures like Araimandi, places excessive load on the lower extremities. [1] This increases the risk of overuse injuries affecting the foot, ankle, knee, and hip. [2] Among these, foot-related problems are particularly common due to continuous exposure to high-impact forces, which may lead to pain, arch flattening, and reduced performance. [1]

Intrinsic foot muscles play a crucial role in maintaining the medial longitudinal arch and ensuring proper weight distribution during weight-bearing activities. Weakness of these muscles can compromise foot stability and balance, further increasing injury risk. Various interventions such as intrinsic muscle strengthening, proprioceptive training and stretching have been used to improve balance and reduce pain in dancers. [1]

Dynamically controlled balance is an important aspect of dance and injury prevention in the world of dancing. In recent years, plyometric exercises that are primarily composed of explosive activities such as jumping and hopping have become quite popular due to their capacity to improve neuromuscular control, strength, and stability. For this reason, it is important to study the impact of plyometric exercises on the dancers' balance and injury prevention.

3. OBJECTIVES

- To examine the effect of Plyometric Exercises on dynamic balance and foot pain in Bharatnatyam dancers using Y-Balance Test and Visual Analogue Scale (VAS).
- To examine the effect of Short Foot Exercises on dynamic balance and foot pain in Bharatnatyam dancers using Y-Balance Test and Visual Analogue Scale (VAS).
- To compare between the Plyometric Exercise and Short Foot Exercise.

4. METHODOLOGY

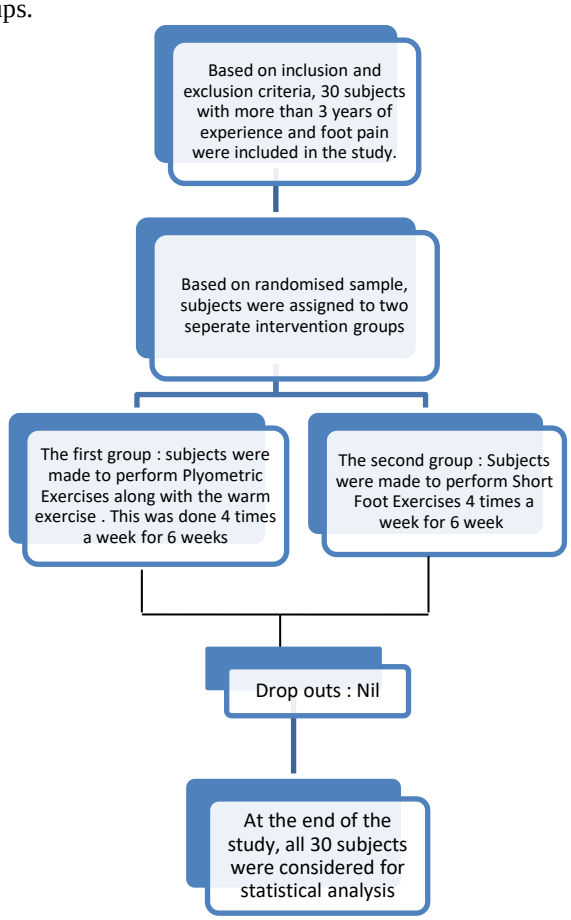
This study was an experimental study with a randomized controlled trial study design. The total number of sample was 30 who were Bharatnatyam dancers with foot pain >4.[14] Their inclusion criteria were age between 18 to 25 years,[12] trained bharatnatyam dancers with at least 3 years of practice, regular practice for 3 years and more, Foot pain ≥ 4 on VAS[14], dynamic balance value < 95 % according to Y Balance test.[15] And the exclusion criteria were patient had undergone lower limb surgery since 1 year[16], ankle injuries, sprains, strains and muscle tears in the past 6 months[16], recent fractures of lower limb in the past 6 month[18], cardio respiratory problems like asthma, angina[19], deep vein thrombosis (DVT).[20] The outcome measure used for understanding the pre and post effect of the interventions on dynamic balance and foot pain was the Y-Balance scale and Visual Analogue Scale (VAS). After

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ethical approval and consent, participants were divided into two groups. Group A performed Plyometric exercises, and Group B performed Short foot exercises. In Plyometric exercise group each session included warm-up and then main exercises. The Y-Balance scale and VAS was recorded before and after the six-week intervention in both the groups.

5. SAMPLING DESIGN

Bharatnatyam dancers between the age of 15 to 25 years who has more than 3 years of experience and having foot pain from dance institutes, colleges and universities were included in the study using convenient sampling.



6. TREATMENT

6.1. First Group

Patients performing warm up before plyometric exercise 2 Sets, 10 Repetitions [21]

MUSCLES	ACTIVATION	DYNAMIC
Hip flexors, quadriceps, gluteus	Forward Jog , Backward Jog	Heel to butt stretch , Angled lunged reach test
Hamstrings	Butt kickers , Linear straight leg bound	Straight leg march , Inverted toe touch , Linear leg swing and lateral leg swing
Abductors	Skipping in place , Carioca steps	Leg cradle
Adductors	Groin skip , Lateral gallop	Sumo squat , Iron cross , Forearm

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6.2. Patient performing Plyometric Exercises[20]

- Front barrier jump – 3 sets :10 reps



- Lateral Barrier Jump – 3 sets : 10 reps



- Lateral high knees with hurdles – 3 sets : 2 reps



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- Depth jump – 3 sets : 8 reps





- Multi direction jumps with hurdle – 3 sets : 6 reps







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- Ankle hops – 3 sets : 10 reps




6.3. The Second Group

Patients performing Short Foot Exercise. [22]

- Toe curl = 3 sets : 10 reps



- Short foot with heel raise – 3sets10 reps



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- Toe spread out and squeeze – 3s sets : 10 reps



- Big toe and lesser toe extension : 3 sets : 10 reps



- Toe walking – 3 sets : 20 sec



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7. STATISTICAL DESIGN

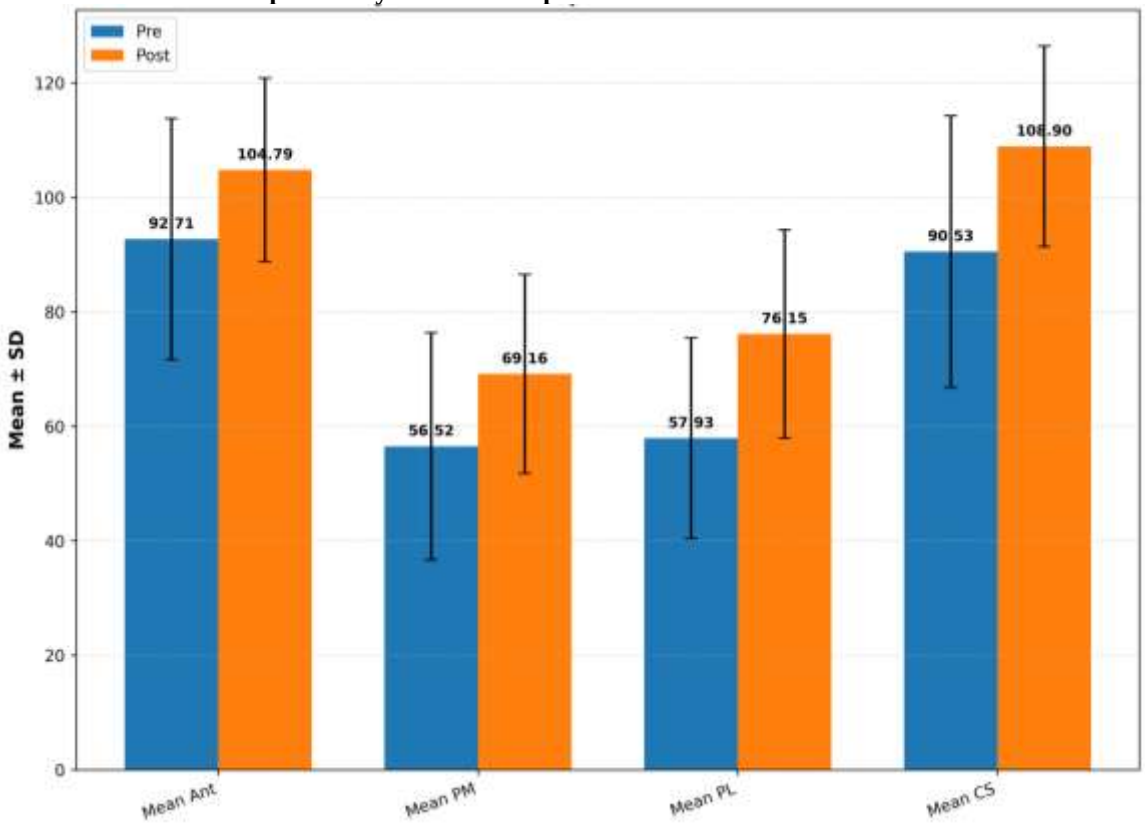
SPSSV26 MS Excel was used to analyze the data, and Microsoft Excel was used to create the tables and graphs. The study included a total sample size of 30 people with ages ranging from a minimum of 15 years to 25 years with minimum 3 years of experience. The overall mean age of Plyometric group is 21.20 ± 2.57, mean years of experience is 8.87 ± 4.96 and mean age of Short Foot group is 20.73 ± 1.98, mean years of experience is 10.27 ± 4.65. The Shapiro-Wilk test 2as used to determine the normality of the data. To understand normality between the groups independent sample T- test is used. Within group comparison of pre and post intervention was done using paired sample T- test. Plyometric group (n=15) showed a statistical significance in Y- Balanced test scores from left posterolateral ($t(14) = -5.36$, $p < .001$), left composite score ($t(14) = -4.28$, $p < .001$), mean posterolateral ($t(14) = -5.10$, $p < .001$), this represented an improvement with effect sizes ranging from moderate to large (Cohen's d = -0.62 to -1.38). The plyometric group showed a highly significant reduction in foot pain, with large effect size. VAS scores decreasing from 5.13 ± 1.25 to 1.73 ± 1.53 ($t(14) = 14.47$, $p < .001$, Cohen's d = 3.74). The short foot group (n=15) showed a significant improvement in selected YBT variables only, namely left posteromedial reach ($t(14) = -3.87$, $p = .002$), left composite score ($t(14) = -3.23$, $p = .006$), and mean posteromedial reach ($t(14) = -3.01$, $p = .009$), shows effect size ranging from moderate to large. The short foot group also showed significant reduction in foot pain, with large effect size.VAS scores improving from 5.07 ± 1.39 to 2.93 ± 1.22 ($t(14) = 8.34$, $p < .001$, Cohen's d = 2.15)

Table 1. Within-group pre-post comparison for the plyometric exercise group

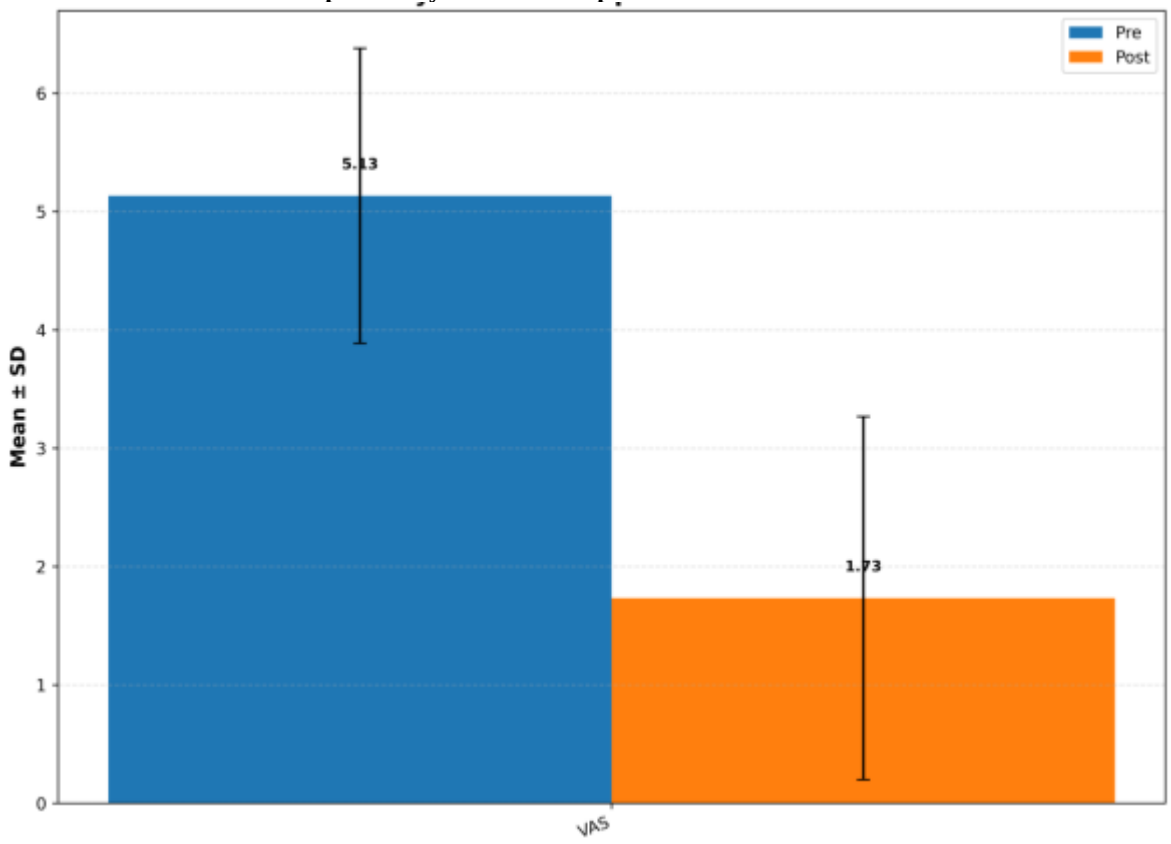
Variable	Pre-intervention Mean ± SD	Post-intervention Mean ± SD	Mean Difference	95% CI	t	Df	P	Cohen's d
YBT Right Ant	92.43 ± 20.54	103.74 ± 17.55	-11.31	[-21.50, -1.13]	-2.38	14	.032*	-0.62
YBT Right PM	55.39 ± 18.45	67.11 ± 15.08	-11.72	[-19.70, -3.74]	-3.15	14	.007*	-0.81
YBT Right PL	58.51 ± 18.11	75.43 ± 21.37	-16.93	[-26.54, -7.31]	-3.78	14	.002*	-0.98
YBT Right CS	90.18 ± 22.93	107.21 ± 17.97	-17.03	[-27.69, -6.37]	-3.43	14	.004*	-0.88
YBT Left Ant	92.99 ± 21.85	105.85 ± 14.81	-12.86	[-22.46, -3.26]	-2.87	14	.012*	-0.74
YBT Left PM	57.65 ± 21.74	71.21 ± 20.08	-13.55	[-22.38, -4.72]	-3.29	14	.005*	-0.85
YBT Left PL	57.36 ± 17.88	76.87 ± 17.75	-19.51	[-27.31, -11.70]	-5.36	14	<.001*	-1.38
YBT Left CS	90.88 ± 24.71	110.60 ± 17.93	-19.73	[-29.60, -9.85]	-4.28	14	<.001*	-1.11
YBT Mean Ant	92.71 ± 21.05	104.79 ± 16.01	-12.09	[-21.80, -2.37]	-2.67	14	.018*	-0.69
YBT Mean PM	56.52 ± 19.83	69.16 ± 17.37	-12.64	[-20.85, -4.42]	-3.3	14	.005*	-0.85
YBT Mean PL	57.93 ± 17.52	76.15 ± 18.21	-18.22	[-25.88, -10.56]	-5.1	14	<.001*	-1.32
YBT Mean CS	90.53 ± 23.70	108.90 ± 17.51	-18.38	[-28.43, -8.32]	-3.92	14	.002*	-1.01
VAS	5.13 ± 1.25	1.73 ± 1.53	3.4	[2.90, 3.90]	14.47	14	<.001*	3.74

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Graph 1A. Plyometric Group: Pre vs. Post Mean YBT Scores



Graph 1B. Plyometric Group: Pre vs. Post VAS Score

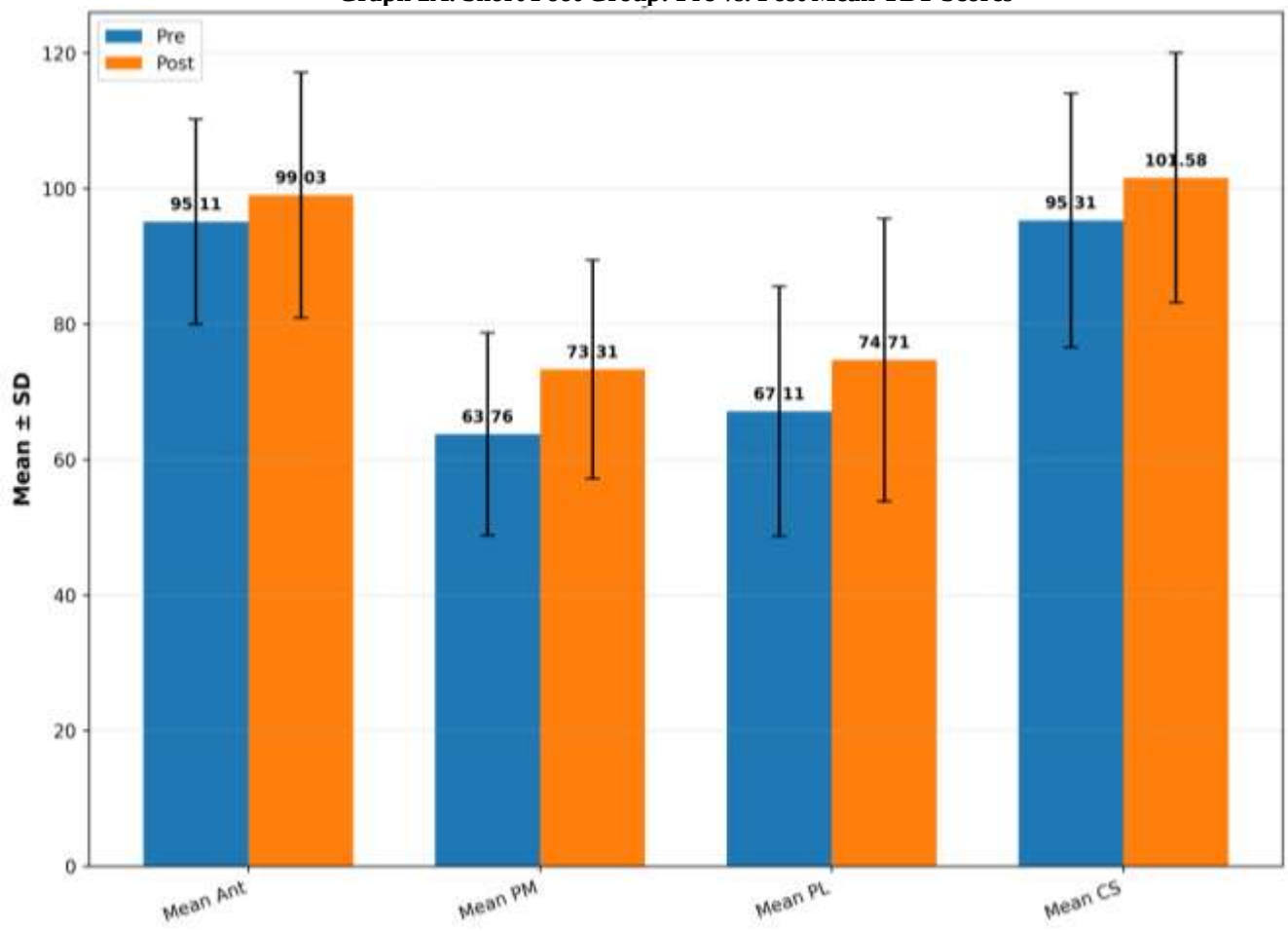


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Table 2. Within-group pre-post comparison for the short foot exercise group

Variable	Pre-intervention Mean ± SD	Post-intervention Mean ± SD	Mean Difference	95% CI	T	Df	P	Cohen's d
YBT Right Ant	94.99 ± 11.82	99.32 ± 16.91	-4.33	[-10.72, 2.05]	-1.46	14	0.168	-0.38
YBT Right PM	64.21 ± 15.03	72.19 ± 15.29	-7.99	[-17.30, 1.33]	-1.84	14	0.087	-0.48
YBT Right PL	65.51 ± 21.41	74.38 ± 23.17	-8.87	[-20.89, 3.15]	-1.58	14	0.136	-0.41
YBT Right CS	97.27 ± 22.30	100.77 ± 17.35	-3.5	[-15.31, 8.31]	-0.64	14	0.535	-0.16
YBT Left Ant	95.24 ± 19.36	98.74 ± 20.23	-3.5	[-8.50, 1.50]	-1.5	14	0.156	-0.39
YBT Left PM	63.31 ± 16.93	74.43 ± 19.58	-11.12	[-17.30, -4.95]	-3.87	14	.002*	-1
YBT Left PL	68.72 ± 17.53	75.04 ± 19.44	-6.32	[-15.52, 2.87]	-1.48	14	0.162	-0.38
YBT Left CS	93.34 ± 17.13	102.40 ± 20.69	-9.06	[-15.08, -3.04]	-3.23	14	.006*	-0.83
YBT Mean Ant	95.11 ± 15.12	99.03 ± 18.11	-3.92	[-8.94, 1.11]	-1.67	14	0.117	-0.43
YBT Mean PM	63.76 ± 14.95	73.31 ± 16.12	-9.55	[-16.36, -2.75]	-3.01	14	.009*	-0.78
YBT Mean PL	67.11 ± 18.44	74.71 ± 20.86	-7.6	[-17.17, 1.98]	-1.7	14	0.111	-0.44
YBT Mean CS	95.31 ± 18.75	101.58 ± 18.44	-6.28	[-13.97, 1.42]	-1.75	14	0.102	-0.45
VAS	5.07 ± 1.39	2.93 ± 1.22	2.13	[1.58, 2.68]	8.34	14	<.001*	2.15

Graph 2A. Short Foot Group: Pre vs. Post Mean YBT Scores



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Graph 2B. Short Foot Group: Pre vs. Post VAS Score

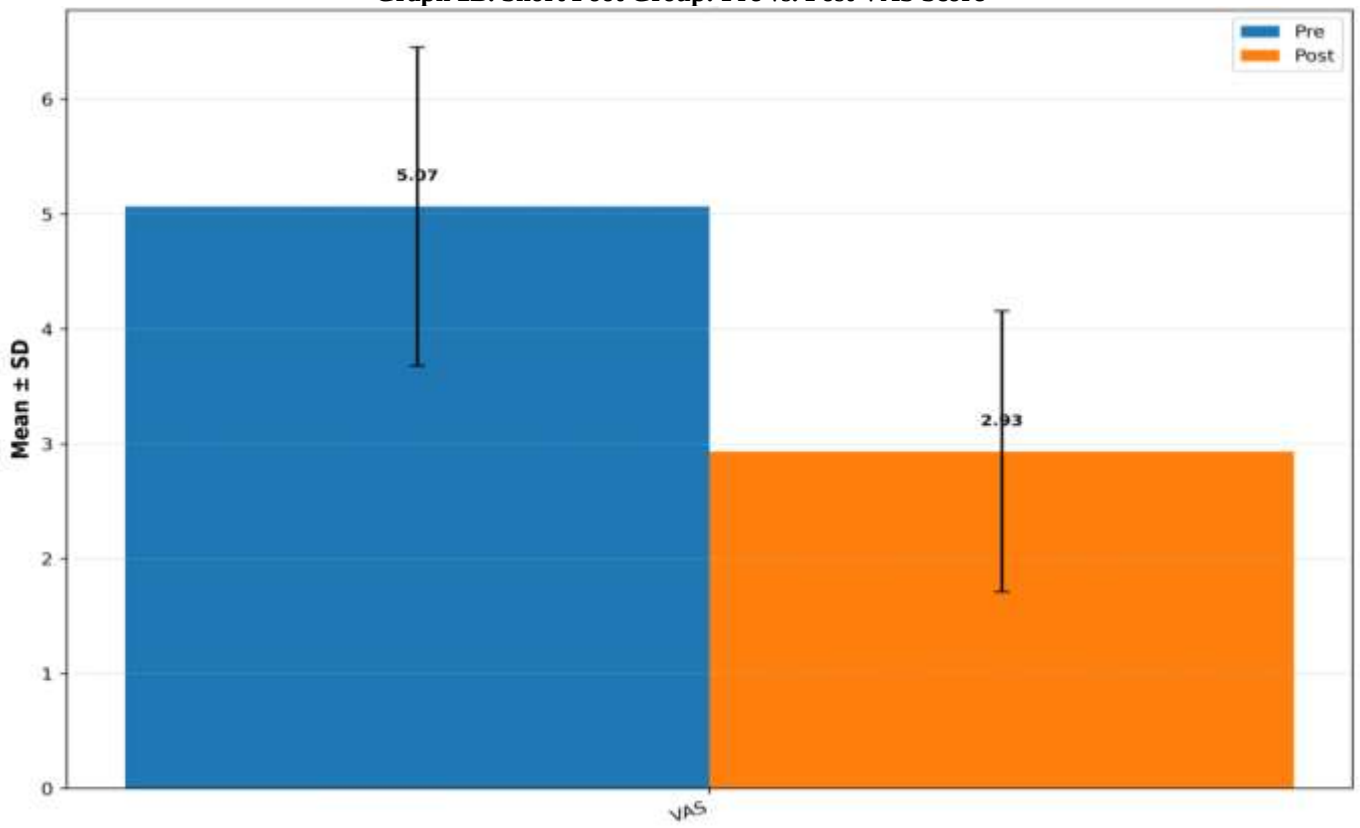
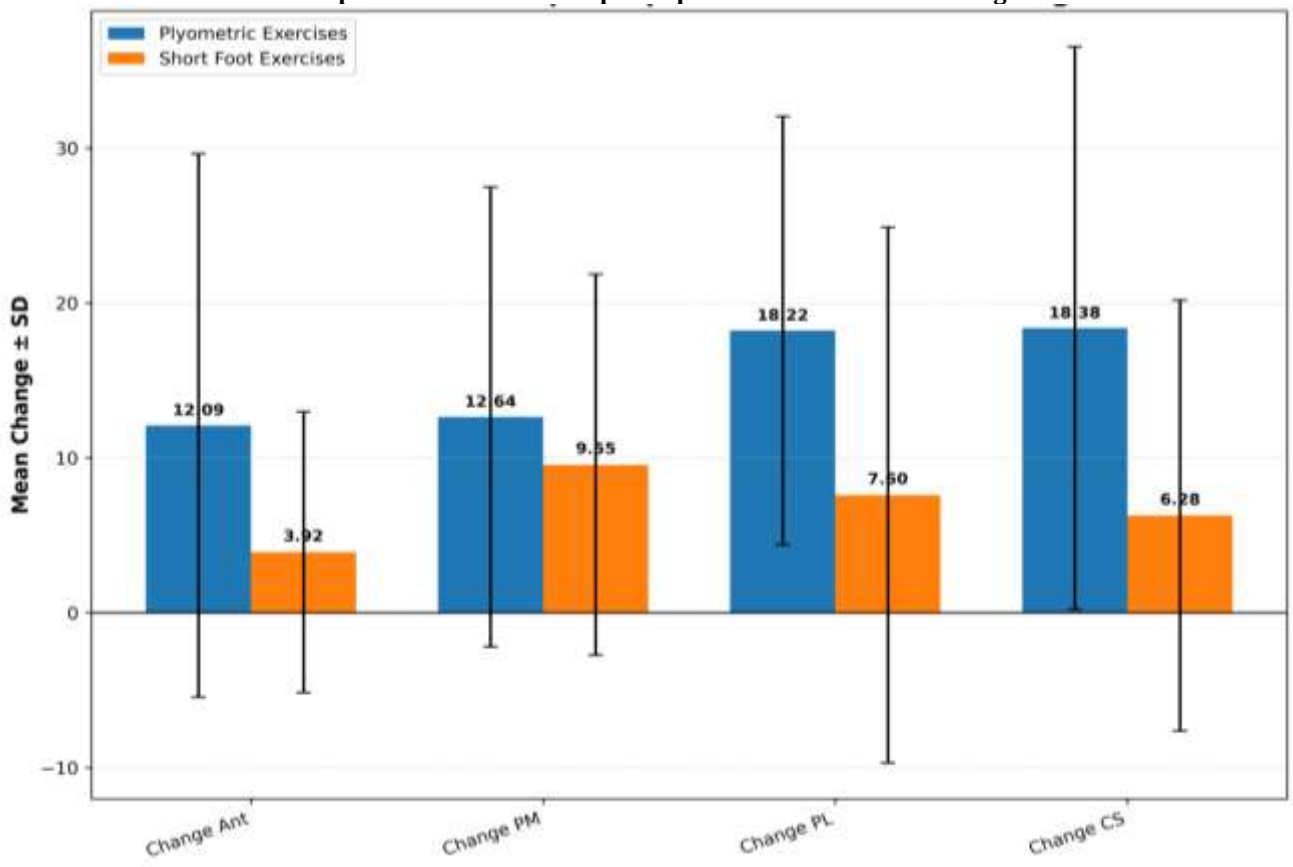


Table 3. Between-group comparison of change scores for all outcome variables

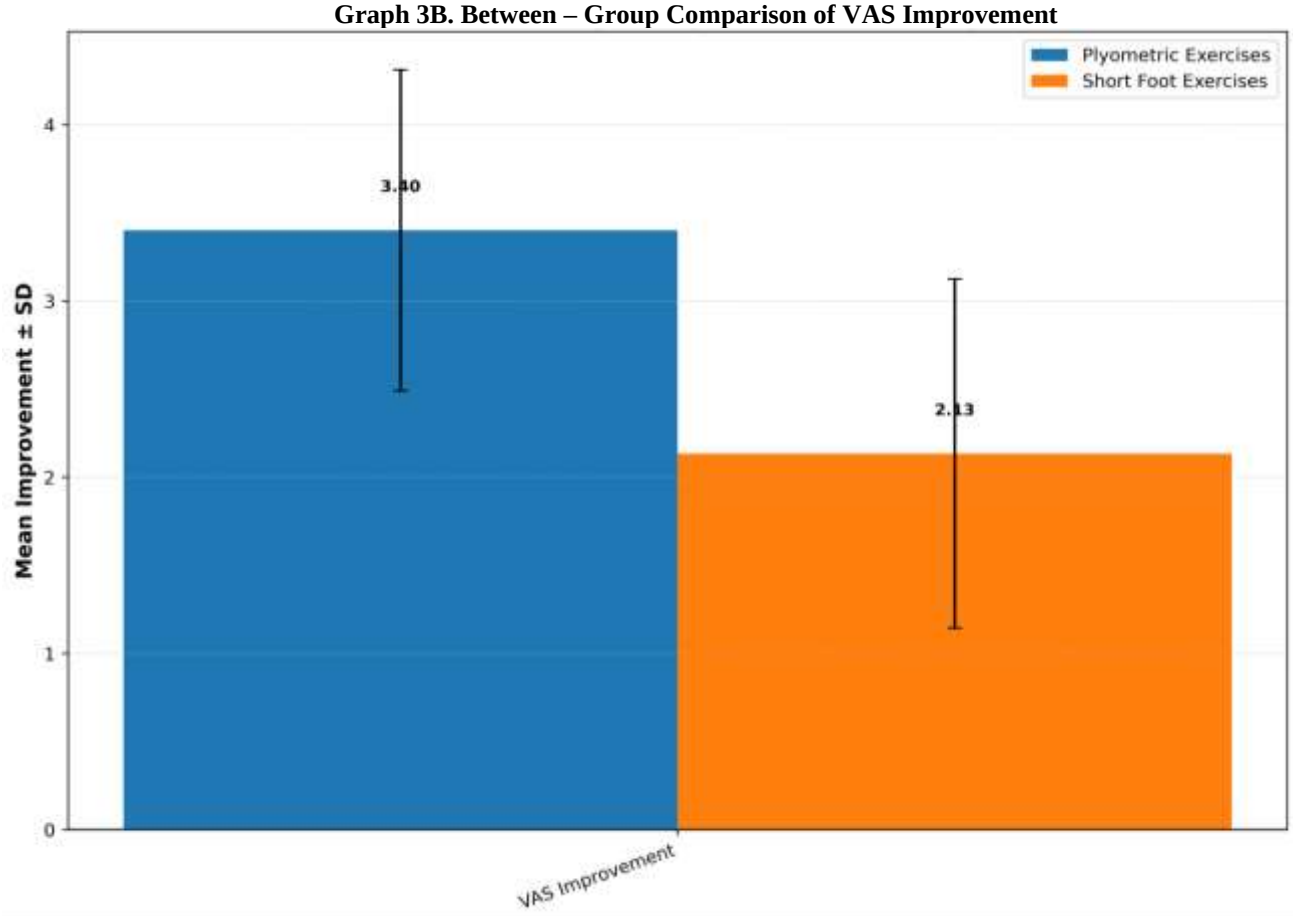
Variable	Plyometric Exercises (n = 15) Mean ± SD	Short Foot Exercises (n = 15) Mean ± SD	Mean Difference	95% CI	T	df	P	Cohen's d
YBT Change Ant	12.09 ± 17.55	3.92 ± 9.07	8.17	[-2.28, 18.62]	1.6	28	0.12	0.59
YBT Change PM	12.64 ± 14.84	9.55 ± 12.29	3.08	[-7.11, 13.27]	0.62	28	0.541	0.23
YBT Change PL	18.22 ± 13.83	7.60 ± 17.29	10.62	[-1.09, 22.33]	1.86	28	0.074	0.68
YBT Change CS	18.38 ± 18.16	6.28 ± 13.90	12.1	[0.00, 24.19]	2.05	28	.050*	0.75
VAS Improvement	3.40 ± 0.91	2.13 ± 0.99	1.27	[0.56, 1.98]	3.65	28	.001*	1.33
YBT Change Right Ant	11.31 ± 18.39	4.33 ± 11.53	6.98	[-4.50, 18.46]	1.25	28	0.223	0.46
YBT Change Right PM	11.72 ± 14.41	7.99 ± 16.82	3.73	[-7.98, 15.45]	0.65	28	0.519	0.24
YBT Change Right PL	16.93 ± 17.36	8.87 ± 21.70	8.05	[-6.65, 22.75]	1.12	28	0.271	0.41
YBT Change Right CS	17.03 ± 19.25	3.50 ± 21.33	13.53	[-1.67, 28.72]	1.82	28	0.079	0.67
YBT Change Left Ant	12.86 ± 17.33	3.50 ± 9.04	9.36	[-0.98, 19.70]	1.86	28	0.074	0.68
YBT Change Left PM	13.55 ± 15.95	11.12 ± 11.15	2.43	[-7.86, 12.72]	0.48	28	0.632	0.18
YBT Change Left PL	19.51 ± 14.10	6.32 ± 16.60	13.18	[1.66, 24.70]	2.34	28	.026*	0.86
YBT Change Left CS	19.73 ± 17.83	9.06 ± 10.87	10.67	[-0.38, 21.71]	1.98	28	0.058	0.72

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Graph 3A. Between - Group Comparison of Mean YBT Change Scores



Graph 3B. Between – Group Comparison of VAS Improvement



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8. RESULTS

The comparison of pre- and post-intervention scores of the Y-Balance Scale showed statistically significant result Plyometric group and of Short foot group significant improvement in selected YBT variables only. There is significant improvement of VAS scores in both the groups.These findings indicate that both interventions were effective in reducing foot pain, but plyometric training was more effective than short foot exercises in improving dynamic balance and achieving greater pain reduction in Bharatnatyam dancers.

9. GEOGRAPHICAL AREA

The study was conducted in Pune, Maharashtra, among bharatnatyam dancers from dance institutions, colleges and universities, having between 15 to 25 years of age and over 33 years of experience.

10. DISCUSSION

In the present study, the effect of Plyometric exercise training on dynamic balance and foot pain among bharatnatyam dancers was assessed. At the end of six weeks, there was an improvement in the Y-Balance score among both the groups but had a statistical difference between the two groups. This implies that Plyometric exercises are more efficient compared to Short Foot exercises to improve dynamic balance. Similarly, VAS did not show any significant difference among the two groups, implying that they are equally efficient to decrease pain.

Plyometric is coined from two Greek words; plythein or plyo which means “to increase,” and metric, meaning “to measure.” It is a form of high-intensity training that emphasizes maximizing the amount of power produced in the least time possible. In Plyometric exercises, the rapid stretching of muscles is immediately followed by muscle contraction in a phenomenon called the stretch-shortening cycle (SSC).[21] Plyometric training improves balance by increasing the efficiency of the body in adapting to sudden changes in body movement, mainly by enhancing neuromuscular control and using the SSC5. [23]

The short foot exercise, a relatively easy-to-perform therapeutic technique, aims at improving the ability of the medial arch to function properly by developing its supporting muscle groups – the intrinsic muscles of the foot. The idea is to perform an activity that would slightly activate deep muscles, whereby the metatarsals of the foot are brought close to the calcaneus.[25] This method is commonly used in athletes' and dancers' training programs.

Considering that both methods are effective in the reduction of pain and improvement of dynamic balance, the latter proved to be superior in terms of improving dynamic balance. It could be explained by the fact that plyometric exercises work on the whole lower limb and develop rapid and functional movement patterns in several joints, thus enhancing neuromuscular coordination and dynamic stability. On the contrary, short foot exercises target the intrinsic muscle of the foot, and hence, dynamic balance is not improved to a great extent but only local stability. These observations indicate that plyometric training is beneficial for dancers since the dynamic loads of the lower extremities are constantly placed on the dancers. [23] Indeed, dancers demonstrate better performance on the Y Balance Test (YBT) after engaging in plyometric training.

For this reason, even though short foot exercises can prove helpful in stabilizing the feet, they are likely to be less helpful than plyometric exercises when it comes to developing balance performance.

11. CONCLUSION

The present study finds that the both plyometric exercises and short foot exercises are done four times a week for six weeks, effectively reduced foot pain and improved balance among the bharatnatyam dancers.

12. FUTURE SCOPE

Long term follow up can help to determine whether the improvement in balance and pain are sustained over time after the intervention. Future studies can include participants from different age groups to understand how age influences the effectiveness of plyometric and short foot exercise interventions. Future studies can include the effect of upper limb plyometric training to better understand its role in overall performance in bharatnatyam dancers.

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