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Research Article

COMPARING THE EFFECTS OF PLYOMETRIC EXERCISES VERSUS FLATFOOT CORRECTIVE EXERCISES ON FOOT POSTURE AND FUNCTIONAL MOBILITY IN OBESE GIRLS WITH FLEXIBLE FLATFOOT

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Abstract

Background: Flexible flatfoot is common in children and may be more prevalent in obesity due to increased mechanical stress on the foot. This study compared the effects of plyometric and flatfoot corrective exercises on foot posture and functional mobility in obese girls with flexible flatfoot.

Methods: A comparative experimental pretest–posttest study was carried out at Santosh College of Occupational therapy, Ghaziabad among 45 obese girls aged 7–12 years, divided into three groups (n=15 each). Experimental Group I received plyometric exercises, Experimental Group II received flatfoot corrective exercises, and the Control Group continued routine physical activities. Interventions were provided for 12 weeks, twice a week. Outcomes were assessed using the Pediatric Balance Scale (PBS), Navicular Drop Test (NDT), and Timed Up and Go (TUG) Test.

Results: The plyometric exercise group showed greater improvements in balance and functional mobility, with PBS scores increasing from 43.07 ± 1.62 to 53.20 ± 1.32 and TUG scores decreasing from 6.49 ± 0.28 to 5.79 ± 0.22 seconds. The flatfoot corrective exercise group demonstrated superior improvements in foot posture, with NDT-L values decreasing from 11.53 ± 0.52 to 6.73 ± 0.46 and NDT-R values decreasing from 11.47 ± 0.52 to 6.93 ± 0.26. Post-intervention analysis revealed statistically significant differences across the outcome measures ($p < 0.001$).

Conclusion: Both interventions improved outcomes, with plyometric exercises showing greater gains in balance and functional mobility, while corrective exercises produced greater improvement in foot posture.

Keywords: Balance, Foot Posture, Flexible Flatfoot, Functional Mobility, Obesity, Plyometric Exercises

1. Introduction

Pes planus, often known as flatfoot, is typified by a diminished or nonexistent MLA, or medial longitudinal arch, which is frequently accompanied by heel valgus and severe pronation. One might categorize the condition as either flexible or rigid. While rigid flatfoot stays flattened under all loading circumstances, flexible flatfoot is distinguished by the existence of a medial longitudinal arch while not bearing weight that flattens during weight-bearing [1].

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Although pediatric flatfoot is frequently asymptomatic, concerns regarding its potential effects on gait, balance, and lower-limb function have increased clinical interest in its management [1]

The foot serves as an important foundation for weight-bearing and postural control. Alterations in foot posture may influence the alignment and function of the entire lower-limb kinetic chain and may be associated with impaired proprioception, reduced balance, and functional instability [2, 3].

These effects may be more pronounced in children with obesity. Increased body mass can increase mechanical loading and plantar pressure, potentially contributing to musculoskeletal alterations and reduced physical activity [4, 5]

Obesity has also been associated with impaired balance and functional mobility, while the

increased mechanical demands placed on the feet may be a factor in the emergence or worsening of flexible flatfoot [4].

Persistent alterations in foot posture may affect functional activities and have been associated with lower-limb musculoskeletal problems, including patellofemoral pain, plantar fascia disorders, Achilles and posterior tibial tendon problems, ankle instability, and other proximal joint abnormalities [5]

. Therefore, early conservative management aimed at improving foot posture, muscular support, balance, and functional performance may be beneficial in children with flexible flat feet.

Exercise-based interventions are commonly used as conservative management strategies for flexible flatfoot. Strengthening the MLA can receive dynamic assistance from the intrinsic and extrinsic foot muscles, while stretching and neuromuscular exercises may improve alignment, postural control, and proprioception [4].

Corrective exercise programs commonly incorporate short-foot exercises, toe exercises, heel raises, and lower-limb stretching to enhance intrinsic muscle activation, support the MLA, reduce excessive pronation, and improve functional stability [5].

Plyometric training represents another exercise-based approach involving rapid eccentric and concentric muscle actions. In children and adolescents, plyometric training has been reported to improve lower-limb power, agility, balance, and dynamic postural control[8]. These adaptations may improve the efficiency of the foot–ankle complex during dynamic activities and potentially contribute to improved functional mobility in children with flexible flat feet.

There is no data directly comparing the effects of plyometric and corrective workouts on foot posture and functional mobility in obese children with flexible flatfoot, especially in females, despite the fact that both may offer functional benefits. Thus, the purpose of this study was to assess how functional mobility and foot posture were affected by plyometric workouts and flatfoot correction exercises in obese females with flexible flatfoot. The results could help determine a suitable exercise-based rehabilitation strategy for enhancing foot posture and functional performance in this group.

1. MATERIAL AND METHODS

2.1 Study Design and Setting

In order to assess the effects of plyometric and flatfoot corrective exercises on foot posture and functional mobility in obese girls with flexible flatfoot, a comparative experimental study was reviewed, discussed, and approved by the Institutional Ethical Committee of Santosh College of Occupational Therapy (Ref No.- SCOT/JULY-25/ECPeads-09). Data was gathered from Santosh Medical College and Hospital, Ghaziabad, and Ignited Minds Special School & Therapy Center, Rohini.

2.2 Participants

The study involved 45 children, who fulfilled the eligibility criteria and were recruited after obtaining informed consent. The inclusion criteria were girls aged 7–12 years with obesity (body mass index 95 percentile or more).Participants were required to have impaired balance, as indicated by a Pediatric Balance Scale (PBS) score ranging from 41–55, flexible flatfoot with a Navicular Drop Test (NDT) measurement of 16–19 mm, and functional mobility within 5–7 seconds on the Timed Up and Go (TUG) test.

Exclusion of Individuals with a history of lower limb injuries requiring medical attention or other conditions that could affect the study's outcomes, including lower-limb deformities, previous surgery, or visual impairment. Girls who had participated in obesity treatment programmes within the previous three months or who were engaged in competitive sports or structured strength and balance training aimed at improving muscle strength or balance were also excluded.

2.3 Intervention

Three groups were randomly assigned to the participants: a Plyometric Exercise Group (EGI), a Flatfoot Corrective Exercise Group (EGII), and a Control Group (CG), with 15 participants in each group. For twelve weeks, the intervention was given twice a week. Each session lasted forty-five minutes and included a five-minute warm-up and cool-down.

TABLE 1: Experimental Group I Protocol[1]

Experimental Group I (EGI): Plyometric Exercise Protocol				
EXERCISE	**SETS**	**REPETITIONS**	**FREQUENCY**	**DURATION**
Jumping Jacks	3	10	2days/week	4mins
Skipping	3	12	2days/week	4mins
Side to Side Jumps	3	12	2days/week	4mins
Forward- Backward Jumps	3	12	2days/week	4mins
Vertical Jumps	3	12	2days/week	4mins
Hopping (Right Foot)	3	10	2days/week	4mins
Hopping (Left Foot)	3	10	2days/week	4mins
Short Forward- Backward Jumps	3	10	2days/week	4mins

TABLE 2: Experimental Group II Protocol[9]

Experimental Group II (EGII): Flatfoot Corrective Exercise Protocol				
Passive Range of Motion (Ankle)	3	10	2days/week	10sec hold
Global movement of foot joints (mobilization)			2days/week	3mins
Calf muscle stretching (Gastrocnemius)	3		2days/week	30sec hold
Soleus muscle stretching	3		2days/week	30sec hold
Peroneus Brevis Stretch	3		2days/week	20sec hold
Anterior Tibialis strengthening (resisted dorsiflexion)	3	12	2days/week	3mins
Posterior Tibialis strengthening (theraband inversion)	3	12	2days/week	3mins
Flexor Hallucis Longus strengthening (toe curl with towel)	3	10	2days/week	3mins
Intrinsic foot muscle activation	3	10	2days/week	10sec
Interosseous Plantaris activation (marble pick-up)	3	10 pickups	2days/week	4mins
Abductor Hallucis strengthening (toe spread)	3	12	2days/week	3mins

Global arch activation (foot doming)	3	10	2days/week	10sec
Single-leg weight bearing with pronation control	3		2days/week	30sec hold
Heel walking	2	20 steps	2days/week	3mins
Toe walking	2	20 steps	2days/week	3mins
Descending inclined surface (controlled descent)	2	10	2days/week	3mins
Balance board training	2		2days/week	2mins

TABLE 3: Control Group (CG) Protocol[10]

Control Group (CG) Protocol	Traditional physical activities such as Walking, classroom activities, free playground play, light running during recess, stair climbing, household play activities; no structured exercise intervention was provided

2.4 Outcome Measures

1. **Pediatric Balance Scale (PBS):**Children's postural control and functional balance were evaluated using the PBS. Higher scores indicate better balance. The overall score is between 0 to 56 and consists of 14 items with scores ranging from 0 to 4.
2. **Navicular Drop Test (NDT):** The NDT was used to assess foot pronation and medial longitudinal arch collapse during weight-bearing. More pronation is indicated by higher findings. Millimeters are used to quantify the difference in navicular height between subtalar neutral and relaxed standing positions.
3. **Timed Up and Go (TUG) Test:** This test was used to assess functional mobility, dynamic balance, and gait performance. It calculates how much time it takes to get up from a chair, go three meters, turn around, come back, and sit down.

2.5 Statistical Analysis

Version 29.0 of the Statistical Package for the Social Sciences (SPSS) was utilized for data analysis. Descriptive statistics, including mean and standard deviation, were used to construct the pre-test and post-test findings for the experimental groups (EGI and EGII) and the control group. The control and experimental groups' baseline and post-intervention differences were compared using an independent samples t-test to determine group homogeneity and treatment effects. Additionally, the effectiveness of the two experimental groups was compared, and the Mann-Whitney U test was used to examine the differences between the combined experimental groups and the control group based on the mean rank scores. $P < 0.05$ was set as the threshold for statistical significance.

3. RESULTS

The current study's findingswere systematically compiled and recorded in a master data sheet for further statistical analysis. To summarize the sample distribution, descriptive statistical techniques were applied to the demographic features of the individuals.

TABLE 4: Descriptive Statistics of outcome measures

Outcome Measure	Group	Mean Pre-test	Mean Post-test	SD Pre-test	SD Post-test
PBS	EGI	43.07	53.2	1.62	1.32
	EGII	41.6	47.53	1.12	1.06
	Control	42	42.6	0.85	1.06
NDT-L	EGI	11.53	8.13	0.52	0.35
	EGII	11.53	6.73	0.52	0.46
	Control	11.53	11.47	0.52	0.52
NDT-R	EGI	11.2	8.2	0.41	0.41
	EGII	11.47	6.93	0.52	0.26
	Control	11.47	11.47	0.52	0.52
TUG	EGI	6.49	5.79	0.28	0.22
	EGII	6.57	6.13	0.15	0.12
	Control	6.57	6.47	0.15	0.15

3.1 Baseline Comparison

There was no statistically significant difference between the experimental and control groups at baselinein all outcome measures before the intervention. The p-values for PBS (p = 0.407), NDT-Left (p = 0.61), NDT-Right (p = 0.668), and TUG (p = 0.768) were all greater than 0.05, indicating that both groups were comparable at baseline. This suggests that any post-intervention changes can be attributed to the treatment rather than initial differences between the groups.

TABLE 5: Baseline Comparison

Scale	Control Group	Experimental Group I	Experimental Group II	t Value	P Value	Interpretation
PRE-PBS	Pre-test PBS	Pre-test PBS	Pre-test PBS	0.842	0.407	No statistically significant difference
PRE-NDT (Left)	Pre-test NDT-L	Pre-test NDT-L	Pre-test NDT-L	-0.516	0.61	No statistically significant difference
PRE-NDT (Right)	Pre-test NDT-R	Pre-test NDT-R	Pre-test NDT-R	-0.433	0.668	No statistically significant difference
PRE-TUG	Pre-test TUG	Pre-test TUG	Pre-test TUG	0.298	0.768	No statistically significant difference

3.2 Post- Intervention Analysis

The post-test comparison between the control and experimental groups showed statistically significant differences in all outcome measures. The p-values for PBS, NDT-Left, NDT-Right, and TUG were all less than 0.001, demonstrating that, in comparison to the control group, the experimental intervention yielded considerably larger benefits.This suggests that the applied exercises were effective in improving balance, foot posture, and functional mobility.

TABLE 6: Post- Intervention Analysis

Scale	Control Group	Experimental Group I	Experimental Group II	t Value	P Value	Interpretation
POST-PBS	Post-test PBS	Post-test PBS	Post-test PBS	6.214	<0.001	Statistically significant difference
POST-NDT (Left)	Post-test NDT-L	Post-test NDT-L	Post-test NDT-L	-7.482	<0.001	Statistically significant difference
POST-NDT (Right)	Post-test NDT-R	Post-test NDT-R	Post-test NDT-R	-7.135	<0.001	Statistically significant difference
POST-TUG	Post-test TUG	Post-test TUG	Post-test TUG	5.964	<0.001	Statistically significant difference

3.3 Mann-Whitney U Test for Experimental I and Experimental II (EGI & EGII)

The rank analysis shows that during the pre-test, the mean ranks of EGI and EGII were relatively close for NDT (13.90 vs 17.10, p = 0.241) and TUG (14.43 vs 16.57, p = 0.516), indicating similar baseline performance on these measures; PBS pre-test mean ranks (19.27 vs 11.73) differed significantly (p = 0.018) though the underlying score difference was small. In the post-test, EGI showed a markedly higher mean rank for PBS (23.00 vs 8.00, p < 0.001) and a lower TUG time reflected in a lower mean rank (9.33 vs 21.67, p < 0.001), while EGII showed a higher mean rank for NDT reduction (23.00 vs 8.00, p < 0.001), indicating that EGI (plyometric exercise) produced greater gains in foot posture and functional mobility, while EGII (flatfoot corrective exercise) produced the greater reduction in navicular drop.

TABLE 7: Mann-Whitney U Test for Experimental I and Experimental II (EGI & EGII)

Scale	Phase	N (each)	Mean Rank EGI	Sum of Ranks EGI	Mean Rank EGII	Sum of Ranks EGII
PBS	Pre-test	15	19.27	289.0	11.73	176.0
PBS	Post-test	15	23.00	345.0	8.00	120.0
NDT	Pre-test	15	13.90	208.5	17.10	256.5
NDT	Post-test	15	23.00	345.0	8.00	120.0
TUG	Pre-test	15	14.43	216.5	16.57	248.5
TUG	Post-test	15	9.33	140.0	21.67	325.0

3.4 Mann-Whitney U Rank of Experimental I + Experimental II and Control Group

The rank analysis between the combined experimental groups (EGI + EGII) and the control group shows that during the pre-test, the mean ranks of the combined experimental group and the control group were similar across all three outcome measures, indicating comparable baseline status. However, in the post-test, the experimental groups showed a substantially higher mean rank for PBS (30.50 vs 8.00) and a substantially lower mean rank for NDT (15.50 vs 38.00) and TUG (15.82 vs 37.37) compared to the control group, suggesting that the experimental interventions produced significantly greater improvement in foot posture, flatfoot severity, and functional mobility than the control condition.

TABLE 8: Mann-Whitney U Rank of Experimental I + Experimental II and Control Group

Scale	Phase	N EGI+EGII	Mean Rank EGI+EGII	Sum of Ranks EGI+EGII	Mean Rank CG	Sum of Ranks CG
PBS	Pre-test	30	23.67	710.0	21.67	325.0
PBS	Post-test	30	30.50	915.0	8.00	120.0
NDT	Pre-test	30	22.20	666.0	24.60	369.0
NDT	Post-test	30	15.50	465.0	38.00	570.0
TUG	Pre-test	30	22.47	674.0	24.07	361.0
TUG	Post-test	30	15.82	474.5	37.37	560.5

3.5 Mann-Whitney Test Statistics of Experimental I & II versus Control Group

The Mann-Whitney U test was employed to evaluate thecombined experimental groups and the control group for each outcome measure. For the pre-test scores, there was no statistically significant difference between the groups for PBS ($p = 0.629$), NDT ($p = 0.505$), or TUG ($p = 0.706$), indicating that all groups were comparable at baseline. However, for the post-test scores, a statistically significant difference was observed for all three outcome measures (PBS: $p < 0.001$; NDT: $p < 0.001$; TUG: $p < 0.001$), demonstrating that the experimental interventions resulted in significantly greater improvement in foot posture, flatfoot severity, and functional mobility compared to the control group.

TABLE 9: Mann-Whitney Test Statistics of Experimental I & II versus Control Group

Scale	Phase	Mann-Whitney U	Z Value	Asymp. Sig. (2-tailed)
PBS	Pre-test	245.000	0.482	0.629
PBS	Post-test	450.000	5.417	<0.001
NDT	Pre-test	201.000	-0.578	0.505
NDT	Post-test	0.000	-5.417	<0.001
TUG	Pre-test	209.000	-0.385	0.706
TUG	Post-test	9.500	-5.189	<0.001

. 4. DISCUSSION:

The goal of the current research was to assess how well plyometric workouts and flatfoot corrective exercises affected the functional mobility, balance, and foot posture of obese girls with flexible flatfoot.The findings demonstrated improvements in all three outcome measures following both exercise interventions, whereas the control group showed relatively minor alterations. The two exercise interventions demonstrated different patterns of improvement, with plyometric exercises showing greater improvement in balance and functional mobility, while flatfoot corrective exercises showed greater improvement in foot posture.

The Pediatric Balance Scale (PBS) scores improved in both experimental groups following the intervention. The mean PBS score increased from 43.07 to 53.20 in EGI, which received plyometric exercises, and from 41.60 to 47.53 in EGII, which received flatfoot corrective exercises. The control group showed only a small increase from 42.00 to 42.60. The greater improvement in PBS observed in EGI may be attributed to the dynamic and repetitive nature of plyometric exercises, which challenge postural control, neuromuscular coordination, and lower-limb stability. Plyometric training involves quick eccentric-concentric movements of the musclesand may improve muscular power and the ability to respond to changes in balance during dynamic activities. These results align with earlierevidence suggesting that plyometric training can enhance balance, agility, muscular power, and neuromuscular control in children[11].

Foot alignment was evaluated using the Navicular Drop Test. Both experimental groups demonstrated reductions in NDT-L and NDT-R values following the intervention, whereas the control group showed minimal change. The greater reductions observed in EGII may be related to the specific focus of flatfoot corrective exercises on the intrinsic and extrinsic muscles supporting the medial longitudinal arch. Exercises targeting the intrinsic foot musculature may improve active arch support and contribute to reduced excessive pronation and improved foot posture. These findings are in agreement with previous studies reporting that foot-specific strengthening exercises can improve medial longitudinal arch support and foot function in children with flexible flatfoot[6].

The Timed Up and Go (TUG) Test, which measures functional mobility, showed improvements in both experimental groups.TUG time decreased from 6.49 to 5.79 seconds in EGI and from 6.57 to 6.13 seconds in EGII, while only minimal improvement was observed in the control group. The greater improvement in EGI may be associated with Plyometric training's impact on lower limbpower, coordination, agility, and dynamic postural control. These adaptations may facilitate more efficient performance of transitional and walking activities. Improvement in the corrective exercise group may also be related to enhanced foot stability and lower-limb alignment resulting from targeted strengthening and control of the foot and ankle complex[12].

The baseline comparisons demonstrated no statistically significant differences between the groups for the measured outcome variables, indicating that the groups were comparable before the intervention. Following the intervention, significant between-group differences were observed in the outcome measures. The different patterns of improvement between EGI and EGII suggest that the two exercise approaches may provide distinct benefits. Plyometric exercises appeared to provide greater benefits for balance and functional mobility, whereas flatfoot corrective exercises produced greater reductions in navicular drop and therefore greater improvement in foot posture[12].

Overall, the findings suggest that both plyometric and flatfoot corrective exercises may be beneficial components of rehabilitation for obese girls with flexible flatfoot. Plyometric exercises may be particularly useful when the rehabilitation goal is to improve dynamic balance and functional mobility, whereas flatfoot corrective exercises may be more appropriate when the primary goal is to improve medial longitudinal arch support and foot posture. These findings encourage the integration ofstructured exercise interventions into rehabilitative initiatives forobese girls with flexible flatfoot while highlighting the importance of selecting exercises according to the desired functional and biomechanical outcomes.

5 CONCLUSION

Both flatfoot corrective and plyometric exercises improved foot posture, balance, and functional mobility in obese girls with flexible flatfoot. Plyometric exercises demonstrated greater improvements in balance and functional mobility, whereas corrective exercises produced greater improvements in foot posture. Structured exercise may therefore be beneficial in the rehabilitation of obese girls with flexible flatfoot, with the choice of intervention potentially guided by the specific functional outcome targeted.

6 DECLARATIONS & ETHICAL STATEMENTS:

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- **Authors' Contributions:** AN conceptualized the study, drafted the protocol, carried out data collection, and wrote the initial manuscript draft. RKS supervised the project

and made critical revisions to the work. PK and SD edited the manuscript and coordinated submission.The final manuscript was read by all authors, who gave their approval.

- **EthicalApproval and Consent: Ethical clearance no.- SCOT/JULY-25/ECPeads-09**All study participants gave their informed consent to participate in the intervention and for data to be published.
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- **AI Disclosure:** Artificial intelligence tools were not used in the conceptualization, execution, data analysis, or manuscript drafting of this study.

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