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Impact of Foot Muscle Exercise with Kinesio-Taping Versus Prefabricated Orthoses on Balance in Obese Adults with Flexible Flatfoot: A Comparative Study.

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KEYWORDS

obesity, balance. Flat foot, foot muscle exercises

ABSTRACT:

Background: Obesity is associated with a higher prevalence of flexible flatfoot, which can impair balance & functional mobility. While both Kinesio-taping & orthotic support is commonly used with foot muscle exercises, their comparative effectiveness for balance improvement in obese individuals with flexible flatfoot remains unclear.

Objectives: To compare the effectiveness of foot muscle exercise combined with kinesio-taping versus foot muscle exercise combined with prefabricated orthosis on static and dynamic balance, as well as foot posture, in obese adults with flexible flatfoot.

Methodology: participants were randomly assigned to 2 groups: Group A received foot muscle exercise combined with kinesio-taping & group B received foot muscle exercise combined with prefabricated orthosis. Outcome measures included the single leg stance test (Static balance), star excursion balance test (dynamic balance), Navicular drop test, & foot posture index.

Results: Both groups showed significant improvements in static balance, dynamic balance, & foot posture following the intervention. However, Group B demonstrated greater improvements in dynamic balance & navicular hight compared to Group A. No significant difference was observed in static balance or overall foot posture index.

Conclusion: Foot muscle exercise combined with either kineo-taping or prefabricated orthotic support effectively improves balance & foot posture in obese adults with flexible flatfoot. However, combining foot muscle exercise with prefabricated orthosis yields superior improvements in dynamic balance & navicular height. Incorporating prefabricated orthotic support alongside exercise is recommended for optimal management of balance & arch support in this population.

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INTRODUCTION

Obesity is a significant risk factor for the development of flat feet in adults, primarily due to the increased mechanical load and constant pressure placed on the foot's supportive structures, which can gradually stretch and weaken the ligaments and tendons responsible for maintaining the arch's integrity.[1,2] Dysfunction of the posterior tibial tendon, crucial for supporting the medial longitudinal arch, is also more prevalent among obese individuals and can accelerate the progression of flatfoot deformity.[2, 3,4]

Altered gait patterns and biomechanical changes commonly observed in obese individuals can contribute to abnormal weight distribution and increased stress on the arches, exacerbating the risk of flatfoot [2]. Importantly, both obesity and flat feet are linked to a higher risk of developing osteoarthritis (OA), as excess body weight and altered foot mechanics increase joint strain and inflammatory responses, accelerating cartilage degeneration and leading to earlier onset and greater severity of OA in the lower limbs[2]. Collectively, these factors highlight the multifactorial relationship between obesity, flat feet, and OA, underscoring the need for targeted interventions in this population.[2,5]

Obesity and acquired flatfoot together have a significant negative impact on postural stability, with early sensorimotor dysfunction of the tibialis posterior (TP) playing a critical contributory role.[2,3] Excess body weight increases the mechanical load on the foot's arches, accelerating the structural collapse that characterizes flatfoot deformity.[1,2] This biomechanical alteration disrupts normal weight distribution and muscle function, making balance more difficult to maintain.[2,6] Importantly, the tibialis posterior not only provides dynamic support to the medial longitudinal arch but also serves a key proprioceptive function, relaying sensory feedback essential for postural adjustments.[2,3]

Early dysfunction of the TP impairs both its motor and sensory roles, leading to reduced arch support and diminished proprioceptive acuity.[2,3]

Studies have demonstrated that as body mass index (BMI) increases, dynamic balance decreases, particularly in individuals with flat feet, due to muscle imbalances and shifts in the centre of mass[2, 6] Furthermore, individuals with flat feet exhibit slower walking speeds and greater postural instability, increasing their risk of falls[2, 6,7] Thus, early sensorimotor impairment of the tibialis posterior, especially in the context of obesity, amplifies balance difficulties and underscores the importance of early intervention targeting both proprioceptive and structural support mechanisms.[2,3,6,7]

Conservative interventions such as foot muscle strengthening exercises, Kinesio-taping, and insole foot orthoses are commonly employed to restore arch integrity, improve balance, and alleviate symptoms[8,9] Kinesio-taping is designed to provide dynamic support to the medial arch and facilitate neuromuscular control, while foot orthoses offer continuous passive support and realignment of the foot structure.[10,11] Despite the widespread use of these interventions, there is limited evidence directly comparing the combined effects of Kinesio-taping with exercise versus exercise plus insole foot orthosis, especially in the context of obesity-related flat foot. Understanding the relative effectiveness of these approaches is crucial for optimizing rehabilitation strategies and improving patient outcomes.

MATERIALS AND METHODOLOGY

INCLUSION CRITERIA

18-40 years of age

Both male and female

BMI >25 kg/ m2

Bilateral asymptomatic flexible flat foot

Navicular drop test >10mm

FPI6 score > +6

EXCLUSION CRITERIA

Structural flat feet

Foot injury due to systemic inflammatory infectious disease in the last 6 months

Foot deformity including hallux valgus, hammer toe, claw toe, limb length discrepancy etc

Inability to perform exercise due to pain around ankle and feet

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History of foot surgery science 6 weeks

Participants with any neuromuscular involvement

Pregnancy

Difficulty in standing and walking due to any condition

SAMPLING & RANDOMIZATION

The sample size:44

Study setting: Anand

Study duration: 6 months

Once ethical approval from institutional board was obtained, eligible patients were randomly allocated by chit box method to two groups.

GROUP A: foot muscle exercise with Kinesio-taping

GROUP B: foot muscle exercise with prefabricated orthosis

PRE-AND POST-TREATMENT EVALUATIONS

Prior to the first therapy ahead of the session, consent was secured from participants in both groups, demographic details were collected. A navicular drop test was taken which measures the navicular height. Foot pressure index which assesses the foot based on a six-factor scoring system. Both dynamic and static balance was accessed with the star excursion balance test and single limb stance test respectively[12,13]. Both groups were given treatment 4 days per week for 4 weeks[14]. Outcome measures were obtained before and after the program schedule.

INTERVENTION

Group A: Foot muscle exercise with Kinesio-taping

<u>Navicular sling technique</u>

Figure 1: Kinesio-taping technique

1. **Short foot exercise[15,16]**

Before the intervention, all participants performed foot and ankle stretching for 5 min to relieve muscle tone and prevent spasms. The SF exercise was accomplished in two stages. An exercise was performed first to shorten the foot in the forward and backward directions along with an attempt to move the metatarsal heads toward the heel without bending the toes. Thereafter, the previous step was performed again by applying an equal load to the three support points of the foot. After performing the SF exercise for 15s, a rest interval of 15s was provided, and one set consisted of four repetitions. SF exercise was performed for about 15 min for a total of five sets. Interventions were performed in the sitting position for weeks 1 to 2 and in the standing position for weeks 3 to 4.

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Figure:2: Short foot exercise

2. **Towel curls exercise**

Place towel under foot, flat. The patient is instructed to sit with heels under the knees with toes pointing forward. Heels should stay in place on a towel. Ask the patient to pull the towel towards the heel, lift the arch and then relax the arch gradually on the count of 5 Perform the same on other feet. This is repeated 15 times three sets for 4 days/week for 4 weeks.[17]

3. **Foot Adduction Resistance Exercise (Tibialis posterior muscle strengthening)**

The patient placed his or her feet on the floor, knee joints bent at a flexion angle of 80°. Elastic bands were provided depending on the patient's muscle strength which was wound around the medial and lateral sides of each subject's foot, tied up, and pulled laterally at an angle of 45° in relation to the floor. This process is repeated 15 times 3 sets for 4 days/week for 4 weeks.
During the exercise, the feet were maintained flat, in contact with the floor, and moved as it they were sweeping the floor.[3]

4. **Heel raises with ball**

The patient is instructed to stand upright. A ball is placed between both the medial malleolus. The patient is instructed to hold the ball between the malleolus and simultaneously raise the heels and return to a neutral position slowly for a count of 5. This is repeated 15 times with three sets for 4 days/week for 4 weeks.[6]

Figure 3: Heel raises with ball

Group B: Foot muscle exercise with prefabricated orthosis

Foot muscle exercise protocol is same as group A & Participants were provided with commercially available prefabricated medial arch support insoles. These insoles are constructed from soft, durable materials such as EVA foam or silicone gel & feature a built in medial arch support along with a cushioned heel for added comfort. The insoles are widely accessible at pharmacies, orthopaedic stores, & online retailers, with commonly used brands including Dr. Scholl's, Vissco, & Tynor. For optimal fit, insoles were selected according to each

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participant's shoe size. Participants were instructed to place the insole in their regular footwear & to wear them during all weight bearing activities throughout the duration of the study period.

RESULT

Table: 1. BASELINE CHARACTERISTICS OF SUBJECTS IN BOTH GROUPS

CHARACTERISTIC	GROUP A MEAN±SD	GROUP B MEAN±SD	p VALUE
AGE (years)	24.90± 6.99	27± 7.59	0.01
BMI (kg/m^2)	29.20± 3.67	28.90± 2.65	0.04

(BMI = Body mass index)

STATISTICAL ANALYSIS

Data were analyzed by using Microsoft Excel 2019. within-group analysis was done by Paired T test and Between groups analysis was Unpaired T test test. Data were analyzed at 5% level of significance with confidence (CI) at 95%.

TABLE 2: WITHIN-GROUP PRE-POST INTERVENTION MEAN FOR NAVICULAR DROP TEST

GROUP	navicular drop test	Pre-intervention Mean±SD (Standard deviation)	Post-Intervention Mean±SD (Standard deviation)	T Value	P Value
GROUP A	**Right**	11.6±0.67	11.5±0.68	0.16	0.32
	Left	11.6±0.69	11.5±0.68	0.16	0.32
GROUP B	**Right**	11.8±1.01	11.6±1.04	3.23	0.03
	Left	11.8±1.04	11.6±1.04	2.52	0.019

Results show statistically significant difference in Group B and no statistically significant difference in Group A.

TABLE 3: WITHIN-GROUP PRE-POST INTERVENTION MEAN FOR FOOT POSTURE INDEX

GROUP	Foot posture index	Pre-intervention Mean±SD (Standard deviation)	Post- Intervention Mean±SD (Standard deviation)	T Value	P Value
GROUP A	**Right**	7.04+0.78	7+0.81	1.7	0.33
	Left	7.04+0.78	7+0.81	1.7	0.33
GROUP B	**Right**	7.68+0.99	7.63+1.00	1	0.32
	Left	7.68+0.99	7.63+1	1	0.32

Results show no statically significant difference in both groups.

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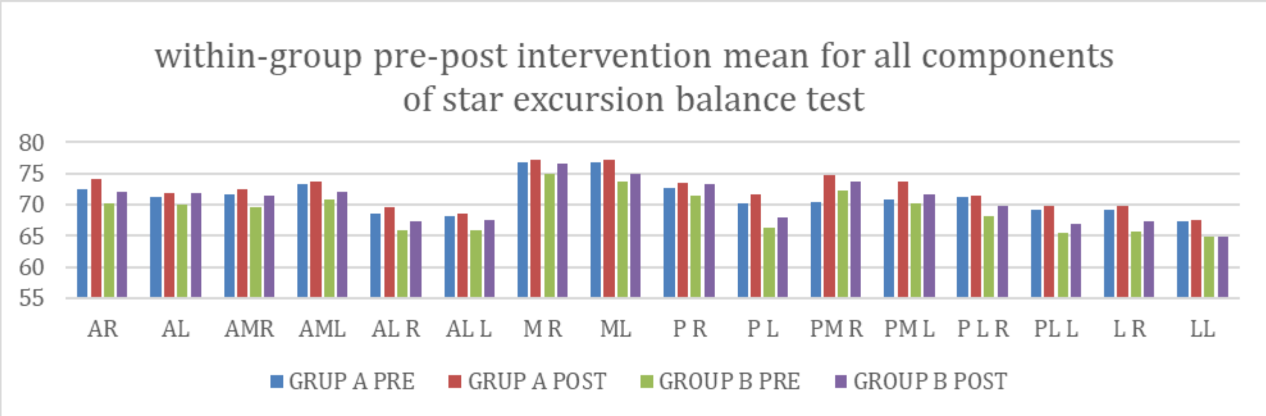
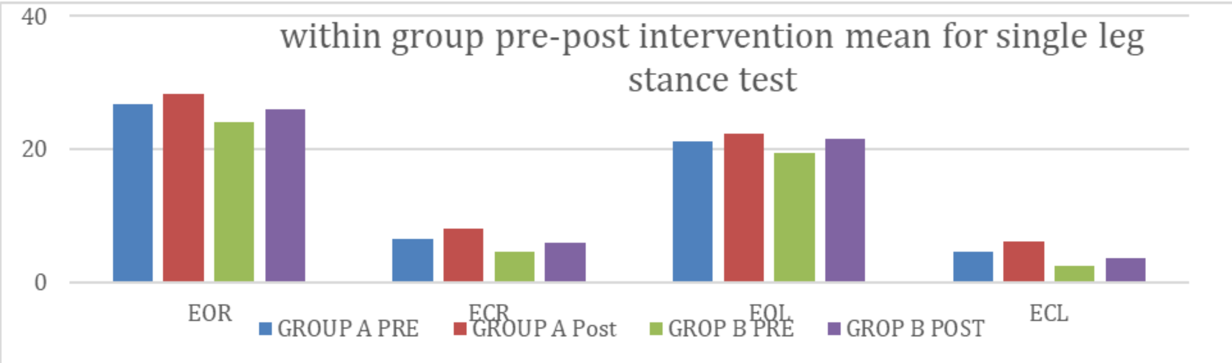
GRAPH 1. WITHIN-GROUP PRE-POST INTERVENTION MEAN FOR SINGLE LEG STANCE TEST



(EOR= Eyes open right side, ECR= Eyes closed right side, EOL= Eyes open left side, ECL= Eyes closed left side)

Results show statistically significant difference in all components of single leg stance test for with in group.

GRAPH 2. WITHIN-GROUP PRE-POST INTERVENTION MEAN FOR ALL COMPONENTS OF STAR EXCURSION BALANCE TEST



(AR= Anterior right, AL= Anterior left, AMR= Anterior medial right, ALR= Anterior lateral right, ALL= Anterior lateral left, MR= Medial right, ML= Medial left, PR= Posterior right, PL= Posterior left, PMR= Posterior medial right, PLR= Posterior lateral right, PLL= Posterior lateral left, LR= Lateral right, LL= Lateral left)

Result shows statistically significant difference in both the groups

TABLE 4: BETWEEN-GROUP MEAN DIFFERENCE IN NAVICULAR DROP TEST

Variable	**Differences between pre- post intervention**		**T value**	**P value**
	Group A Mean±SD (Standard deviation)	**Group B Mean±SD (Standard deviation)**		
Right	0.009±0.04	0.13±0.19	-2.93	0.007
Left	0.009±0.042	0.1±0.19	-2.25	0.03

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Result shows statistically significant difference in navicular drop test.

TABLE 5: BETWEEN-GROUP MEAN DIFFERENCE IN FOOT POSTURE INDEX

Variable	Differences between pre and post-intervention		T value	P value
	Group A Mean±SD (Standard deviation)	Group B Mean±SD (Standard deviation)		
Right	0.04±0.2	0.04±0.21	0	1
Left	0.04±0.2	0.04±0.21	0	1

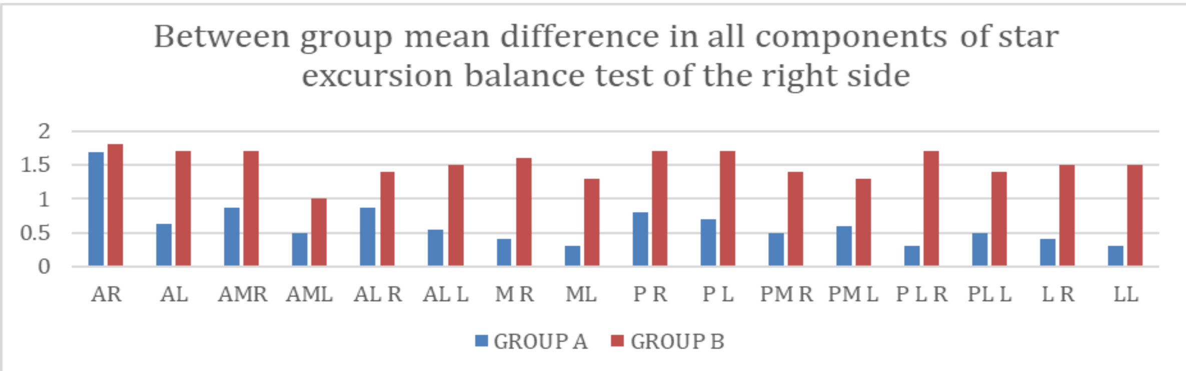
Result shows no statistically significant difference in foot posture index

TABLE 6: BETWEEN-GROUP MEAN DIFFERENCE IN SINGLE-LEG STANCE TEST

Variable	Differences between pre- and post-intervention		T value	P value
	Group A Mean±SD (Standard deviation)	Group B Mean±SD (Standard deviation)		
Eyes open Right side	1.54±0.67	2±1.19	1.55	0.12
Eyes Closed Right side	1.54±0.85	1.36±0.72	-0.7	0.45
Eyes open left side	1.13±2.12	2.09±1.57	1.6	0.09
Eyes closed left side	1.59±0.66	1.18±0.79	-1.85	0.07

Results show no statistically significant difference in all components of single leg stance test for between group analysis.

GRAPH 3. BETWEEN GROUP MEAN DIFFERENCE IN STAR EXCURSION BALANCE TEST.



R= Anterior right, AL= Anterior left, AMR= Anterior medial right, ALR= Anterior lateral right, ALL= Anterior lateral left, MR= Medial right, ML= Medial left, PR= Posterior right, PL= Posterior left, PMR= Posterior medial right, PLR= Posterior lateral right, PLL= Posterior lateral left, LR= Lateral right, LL= Lateral left)

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Between group result for star excursion balance test showed statistically significant difference in both group and no statistically significant difference in anterior and anterior lateral direction of group A

DISCUSSION

Subjects in both groups were matched for age and BMI to minimize baseline differences, with mean ages of 24.9 (Group A) and 27 (Group B), and mean BMIs of 29.2 (Group A) and 28.9 (Group B), respectively.

In the present study, both groups demonstrated statistically significant within-group improvements in the Navicular Drop Test, indicating that both intervention strategies were effective in supporting the medial longitudinal arch. This aligns with findings by Gheitasi et al., who reported that both intrinsic and extrinsic muscle strengthening exercises can enhance dynamic support of the foot arches and improve foot posture by increasing navicular height, as strengthening the foot muscles provides dynamic support to the arches.[18]

For the Single Leg Stance Test, both groups also showed significant within-group improvements in static balance. This is consistent with Rowley et al., who found that activation and strengthening of both intrinsic and extrinsic foot muscles are essential for single-limb support and postural stability.[19]

Similarly, both groups exhibited significant within-group improvements in the Star Excursion Balance Test, reflecting enhanced dynamic balance. Sumaira et al. also reported that strengthening both intrinsic and extrinsic foot muscles contributes to better dynamic balance.[20]

However, when comparing between groups, the present study found that Group B (foot muscle exercise + insole foot orthosis) demonstrated significantly greater improvements in the Navicular Drop Test and dynamic balance measures compared to Group A (foot muscle exercise + Kinesio-taping). This finding is supported by Khisty et al., who observed that interventions providing continuous structural support—such as heel raise exercises and orthoses—are more effective in improving navicular height and correcting the longitudinal arch than interventions relying solely on dynamic or temporary support[21]. Foot orthoses provide consistent, passive support to the medial longitudinal arch throughout weight-bearing activities, redistributing plantar pressure and improving lower limb alignment.[22,23] In contrast, Kinesio-taping offers only temporary support and relies on proper application and skin tolerance, with its effects diminishing over time.[24,25] Orthoses also facilitate neuromuscular adaptation by maintaining optimal foot posture during both static and dynamic activities, which is particularly beneficial for individuals with flexible flat feet and higher body mass.[22,23]

For the Foot Posture Index, no statistically significant difference was observed between groups, which is in agreement with Kavya et al., suggesting that both interventions can positively influence foot posture but the effect may be more pronounced in specific dynamic or functional measures.[26]

No significant between-group difference was found for the Single Leg Stance Test, consistent with Hajirezayi et al., indicating that both interventions are effective for static balance.[27]

Regarding the Star Excursion Balance Test, Group B showed statistically significant improvements in overall dynamic balance compared to Group A, except in the anterior and anterolateral directions for Group A. Lee et al. highlighted that extrinsic muscle training, especially targeting the tibialis posterior, is crucial for maintaining the medial longitudinal arch during dynamic weight-bearing and that structural support from orthosis further enhances this effect.[28]

CONCLUSION

Both foot muscle exercise combined with Kinesio-taping and foot muscle exercise combined with insole foot orthosis are effective in improving static balance, dynamic balance, and foot posture in obese individuals with flexible flat feet. However, the combination of foot muscle exercise and insole foot orthosis provides greater improvements in dynamic balance and navicular height compared to the Kinesio-taping group. This suggests that adding insole foot orthosis to a structured exercise program offers superior benefits for enhancing arch support and functional stability in this population. Therefore, for optimal management of obese flat foot, incorporating insole foot orthosis alongside targeted foot muscle exercises is recommended.

FUTURE DIRECTIONS

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Future studies should consider incorporating a blinded study design to minimize potential bias in both intervention delivery and outcome assessment. Extending the duration of the intervention and follow-up periods would help determine the long-term effectiveness and sustainability of these approaches. Additionally, including gait analysis and other functional parameters could provide a more comprehensive understanding of how these interventions impact walking mechanics and overall mobility in individuals with flat feet. These enhancements would strengthen the evidence base and guide more effective management strategies for this population.

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