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Effects of Elastic Band Exercise on Navicular Drop, Foot Posture Index and Muscle Strength on Young Adults with Flexible Flat Feet

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ABSTRACT

Background: In India, the prevalence of flexible flat feet of 18-25-year-old adults was 13.6% (males-12.8%, females-14.4%). Furthermore, it has been regarded as a potential risk factor for lower limb injuries, such as anterior cruciate ligament rupture, patellofemoral pain syndrome, and hip joint pain. The present study aims to study the effect of elastic band strengthening on navicular drop, foot posture index, and muscle strength in young adults with flexible flat feet
METHOD: Samples of 56 patients with bilateral flat feet with a mean age of 18-25 years were randomly recruited in the elastic band strengthening exercise group and non-elastic band strengthening exercise group. The intervention to both the groups was given 3 days per week for consecutive 4 weeks, and the outcomes in the form of Navicular Drop(ND), Foot Posture Index(FPI), and muscle strength were measured pre-intervention and post-intervention for 56 participants (28 in each group).
RESULTS: Both elastic band strengthening exercises and elastic band strengthening exercises are therapeutically beneficial in participants with bilateral flexible flat feet. However, elastic band strengthening gives added effects to improve navicular drop, foot posture index, and muscle strength.
CONCLUSION: Both elastic band strengthening exercise and non-elastic band strengthening exercises are therapeutically beneficial in participants with bilateral flexible flat feet, however, elastic band strengthening gives added effects to improve navicular drop (ND), foot posture index (FPI), and muscle strength.

Keywords: *Flexible flat feet, MLA, Navicular Drop, and Foot posture Index*

INTRODUCTION

Flat foot, a persistent foot condition, is characterized by hindfoot valgus, midfoot abduction, and flattening of the medial longitudinal arch (MLA).(1) It is further classified into Rigid Flat Feet and Flexible Flat Feet (FFF). In FFF, the MLA is lost during weight-bearing (closed kinematic chain conditions) but is present in open kinematic conditions. However, in both open and closed kinematic chain scenarios, Rigid flat feet result in the loss of MLA height. (2)
Flexible flat feet are the most common foot condition present in both children and adults. It is often referred to as abnormal or excessive pronation, leading to prolonged hypermobility of the subtalar joint complex or pronation when bearing weight. In India,

13.6% of individuals aged 18 to 25 have flexible flat feet, with a prevalence of 12.8% in males and 14.4% in females.[3]

Various factors contribute to flat feet, including age, gender, foot length, family history, early shoe-wearing, body mass index, and coexisting illnesses. [1] Flat feet are also considered a risk factor for lower limb injuries such as anterior cruciate ligament rupture, patellofemoral pain syndrome, and hip joint pain. Symptoms include reduced body efficacy, early fatigue, knee and back pain, and potential deformities. [4]

Clinically, flatfoot can be diagnosed using techniques such as clinical diagnosis, radiographic tests, and footprint analysis.[5] Two primary clinical instruments used to evaluate flat feet with little or no risk are the Navicular Drop Test (NDT) and the Foot Pressure Index (FPI). [6] The tibialis posterior tendon is vital for maintaining the medial longitudinal arch (MLA) in the foot. Ligaments attached to the navicular bone also play a crucial role in human bipedal biomechanics. The Navicular Drop Test (NDT), developed by Brody in 1982, is a common clinical method to assess MLA. It measures the difference in navicular tuberosity height between neutral and relaxed foot postures, with higher NDT results associated with subtalar pronation and lower MLA. The Foot Posture Index (FPI) measures each foot's posture, which includes palpation of the talus head, supra curvature and lateral infra malleolar, calcaneus position in the frontal plane, prominence of the talonavicular region, internal longitudinal arch congruence, and forefoot abduction or adduction concerning the rearfoot. The positive numbers indicate a pronated foot. [7]

Treatment for flat feet in adults depends on the underlying cause. Non-surgical options include foot orthotics, NSAIDs for pain relief, insoles, physical therapy, and exercises targeting arch-supporting muscles to improve balance control and plantar pressure distribution. Foot muscle exercises, specifically targeting intrinsic and extrinsic muscles, play a crucial role in stabilizing the foot and providing dynamic support to the MLA during locomotion [8]

The inherent muscles within the foot (IFM) play a crucial role in stabilizing the foot and contribute to the subsystems of the foot core. When walking, these muscles undergo eccentric lengthening, generating negative work, followed by concentric shortening, which produces positive work. The foot's spring-like mechanism contributes 8%-17% of the body's energy per step.[9] Extrinsic foot muscles (EFM), includes the Tibialis Posterior (TP) and Peroneus Longus (PL), offer dynamic support to the MLA during the stance phase of locomotion and aid in intertarsal joint stabilization.[10]

Recent research highlights the significance of targeted exercises, specifically short foot muscle exercises (SFE), to strengthen intrinsic foot muscles, thereby enhancing foot postural balance and addressing concerns such as excessive pronation. Positive results have been observed in treating flexible flat feet in young individuals through the implementation of SFE. However, the evidence for sustained and long-term effectiveness is currently limited. A potential drawback lies in the exclusive emphasis on intrinsic foot muscle exercises, as this approach neglects the strengthening of extrinsic foot muscles, presenting challenges in improving posture, alignment, and the overall biomechanical chain [11]

Recent studies also highlight the benefits of incorporating elastic bands into exercise routines to enhance muscle recruitment, volume, and overall strength. While some evidence supports the use of elastic bands in improving dynamic balance among children with flat feet, there is a notable gap in research examining their effects on parameters like navicular drop, foot posture index (FPI), and foot muscle strength in young adults with flexible flat feet.[12] The research aims to fill this gap by investigating the specific impact of elastic band exercises on navicular drop, foot posture index, and muscle strength within this particular population.

MATERIALS & METHODS

Prior to commencing the study, IEC approval was taken from "Institutional Ethics Committee (IEC)" of HM Patel Centre for Medical care and Education, Karamsad. The participants who showed interest voluntarily were recruited from Shree Krishna Hospital campus. A total of 56 participants were recruited. Inclusion criteria i.e., bilateral flexible flat feet, 20-25 years of age both gender, navicular drop >10mm, Normal BMI and asymptomatic and exclusion criteria Foot/ankle trauma ,Receiving feet muscle strengthening within last 3 month, Neurological disorders, Any other musculoskeletal disfigurement was assessed and an informed consent was taken from those participants.[12] Detailed information about purpose of the study, study duration and its benefits were conveyed to the participants as per the conditions Then Participant information sheet were obtained from the participants at the Physiotherapy department, Shree Krishna Hospital .

Participants recruited were randomly allocated in two groups - Elastic band strengthening group (A) and control group (B). After taking the consent, prior to intervention; baseline data of all the participants were obtained in the form of demographic data, brief assessment and Navicular Drop (ND) test, Foot Posture Index(FPI) and Foot muscle Strength using Hand Held Dynamometer were assessed as outcome measure and values were documented.

In both the group exercises were given as a 4-week exercise training program in which the participants were called in physiotherapy department for the treatment thrice a week and 3 sets with 10-12 repetitions in each treatment session.

GROUP A:[12]

Participants in the intervention group will use the elastic band and perform all the exercise in the form of Pronation-supination in sitting position with extended knees, Short foot muscle exercises, tip-toeing in one leg standing position while holding to a static bar. Exercise will be contemplated into feet movement training using elastic band with overload principle.

GROUP B:[12]

Control group will have same exercise in the form of Pronation-supination in sitting position with extended knees, short foot muscle exercises, tip-toeing in one leg standing position while holding to a static bar without elastic band.

STATISTICAL ANALYSIS

It is a randomized controlled trial, wherein the participants were allocated in two groups. The randomization was carried out by using Winpipe software.

Descriptive Statistics [Mean (SD), Frequency (%)] were calculated to depict the baseline profile of the study participants. Paired t-test was used to assess the changes in mean ND score, FPI score, and Muscle strength for both groups. An independent sample t-test was used to compare the differences of ND score, FPI score, and Muscle strength for both groups A p-value<0.05 was considered significant.

RESULT

Table 1: Baseline Demographic Characteristics of Participants In Both Groups

GROUP	NO. of Patricipants	AGE (Mean ± SD)	BMI (Mean ± SD)	Female n(%)	Male n(%)
A	28	21.96 ±1.43	21.79 ±1.87	64.2 %	35.7%
B	28	21.64 ±1.64	21.87 ±1.73	60.7%	39.2%

The above table suggests homogeneous distribution of age, BMI, female and male participants included in study at baseline in both the groups

Table 2: Within Group Comparison of Navicular Drop (ND)

GROUP	Right ND			Left ND		
	PRE-Mean ± SD	POST Mean ± SD	p-Value	PRE Mean ± SD	POST Mean ± SD	p-Value
A	12.14± 1.21	8.79 ± 1.03	<0.05	12.21 ± 1.23	8.79 ±1.03	<0.05
B	12.21± 1.10	9.46 ± 1.14	<0.05	12.07 ± 0.94	9.43 ± 1.03	<0.05

Table 2 shows that statistical significance i.e., p-value <0.05 was obtained in both the groups.

Table 3: Within Group Comparison of FPI

GROUP	Right FPI			Left FPI		
	PRE-Mean ± SD	POST Mean ± SD	p-Value	PRE Mean ± SD	POST Mean ± SD	P-Value
A	10.03 ±1.10	6.96 ± .96	<0.05	10.10 ± 1.13	7 ± 0.98	<0.05
B	9.86 ±0.97	7.74 ±1.10	<0.05	9.86 ± 0.93	7.75 ±1.04	<0.05

Table 3 shows that statistical significance ie., p-value <0.05 was obtained in both the groups.

Table 4: Within Group Comparison of Muscle Strength

	GROUP	Right			Left		
		PRE-Mean ± SD	POST Mean ± SD	p-Value	PRE-Mean ± SD	POST Mean ± SD	p-Value
Dorsiflexors	A	8.80± 1.01	11.16 ± 1.34	<0.05	8.78 ±1.04	11.16 ± 1.34	<0.05
	B	8.47 ±.97	9.94 ± 1.15	<0.05	8.49 ±.98	9.94 ± 1.15	<0.05
Plantarflexors	A	10.65 ± 1.33	12.80 ± 1.23	<0.05	10.65 ± 1.33	12.80 ± 1.23	<0.05
	B	10.3 ± 1.16	11.52 ± 1.19	<0.05	10.29 ± 1.15	11.51 ± 1.19	<0.05
Evertors	A	5.23 ± 0.65	7.23 ± 0.77	<0.05	5.23 ± 0.65	7.23 ± 0.77	<0.05
	B	5.06 ± 0.64	6.35 0.81	<0.05	5.06 0.64	6.35 ± 0.81	<0.05
Invertors	A	5.89 ± 0.65	8.09 ± 0.87	<0.05	5.90 ± 0.64	8.09 ± 0.87	<0.05
	B	5.81 ± 0.64	7.10 0.75	<0.05	5.81 0.64	7.10 ± 0.75	<0.05
Toe Flexors	A	15.91 ± 0.94	18.46 ± 0.80	<0.05	15.91 ± 0.94	18.46 ± 0.80	<0.05
	B	15.92 ± 0.70	17.28 ± 0.63	<0.05	15.94 ± 0.70	17.28 ± 0.63	<0.05

Table 4 shows that statistical significance ie., p-value <0.05 was obtained in both the groups.

Table 5: Between group comparison of ND post intervention

	Right			Left		
	Mean ± SD	Mean Difference	p-value	Mean ± SD	Mean Difference	p-value
A	3.35 ± 0.67	0.607	<0.05	3.42 ± 0.74	0.785	<0.05
B	2.75 ± 1.0			2.64 ± 0.98		

Table 5 shows that statistical significance ie., p-value <0.05 was obtained in group A

Table 6: Between group comparison of FPI post intervention

	Right			Left		
	Mean ± SD	Mean Difference	p-value	Mean ± SD	Mean Difference	p-value
A	3.07 ± 0.53	1	<0.05	3.10 ± 0.56	1	<0.05
B	2.07 ± 0.53			2.10 ± 0.56		

Table 6 shows that statistical significance ie., p-value <0.05 was obtained in group A

Table 7: Between group comparison of muscle strength post intervention

	GROUP	Right			Left		
		Mean ± SD	Mean Difference	p-Value	Mean ± SD	Mean Difference	p-Value
Dorsiflexors	A	-2.36 ± 0.66	-0.89	<0.05	-2.38 ± 0.61	-0.93	<0.05
	B	-1.46 ± 0.39			-1.44 ± 0.42		
Plantarflexors	A	-2.15 ± 0.74	-0.93	<0.05	-2.15 ±0.74	-0.93	<0.05
	B	-1.22 ±0.39			-1.21 ± 0.74		
Evertors	A	-2.00 ± 0.47	-0.71	<0.05	-2.00 ± 0.47	-0.71	<0.05
	B	-1.28 ± 0.46			-1.28 ± 0.46		
Invertors	A	-2.2 ± 0.45	-0.90	<0.05	-2.18 ± 0.45		<0.05
	B	-1.29 ± 0.28			-1.28 ± 0.27	-0.9	
Toe Flexors	A	-2.55 ± 0.42		<0.05	-2.55 ± 0.43	-1.21	<0.05
	B	-1.36 ± 0.51	-1.18		-1.34 ± 0.49		

Table 7 shows that statistical significance ie., p-value <0.05 was obtained in group A

DISCUSSION

The average age was 21 years in both the groups. Some of the causes of FFF in this age groups are muscle weakness and foot imbalance. Trauma, excessive use, reduced collagen synthesis, rheumatoid arthritis, neurologic illnesses and neuromuscular disorders, pregnancy, postural problems, gender, and obesity are some of the other factors.[13] Aenumulapalli et al., revealed a higher incidence of flat foot in females than in males, showing results comparable to the current study. In this study, 62.5% of females and 37.5% of males had flexible flat feet.[14] Females with wider pelvises have increased lumbar lordosis because their COG shifts anteriorly, generating an increase in Q angle and collapsed arches in weightbearing, resulting in flexible flat feet. Tri Suciati et al. discovered that in overweight/obese people, the midfoot area is most influenced by the sole's contact with the ground and receives more pressure during weight bearing. Structural alterations can impair the functional capacity of the medial longitudinal arch.[60] However, in this study, participants with normal BMI were enrolled, removing the influence of excess fat in the body on flat feet.[15]

In this study, participants were instructed to perform a tip-toe exercise focusing on maintaining the arch of their feet, commonly known as toe curl. This activity targeted specific muscles including the flexor digitorum longus-brevis, lumbricales, and flexor hallucis longus, while tip-toeing targeted the plantar flexor muscles. Weight-bearing activities involve the interplay of bone structures, ligaments, and intrinsic and extrinsic foot muscles to control overpronation and maintain the medial longitudinal arch (MLA). Extrinsic muscles, such as the anterior posterior tibial and long peroneus muscles, contribute to midtarsal joint stabilization and dynamic support of the MLA during the stance phase, aiding in the control of overpronation.

Rehabilitating these muscles is crucial for preserving the MLA and improving Navicular Drop (ND). The intrinsic foot muscles, including the hallucis abductor, short digitorum flexor, and interosseous muscles, play a key role in foot stabilization. Studies by Jung Dy et al. and Hagen SL et al. highlight the significance of intrinsic muscles, particularly the hallucis abductor, in supporting the MLA and stabilizing the midtarsal joint during propulsion and resisting pronation ground reaction forces.[16,17]

The study incorporated exercises such as foot shortening, supination-pronation, and tiptoeing to strengthen both intrinsic and extrinsic foot muscles. Research by Jung Dy et al. suggests that foot shortening exercises are more effective than toe curl exercises in strengthening the hallucis abductor muscle, especially when performed in a one-leg standing position.[16]

The combined exercise regimen targeting both intrinsic and extrinsic foot muscles had a statistically significant effect within the study group, leading to improvements in ND, Foot Posture Index (FPI), and muscle strength. This supports the idea that a comprehensive approach to foot muscle exercises can positively impact foot posture and stability.

In terms of muscle recruitment, volume, and strength, specialized exercises with elastic band application offer several advantages. According to Kraemer WJ et al., muscles respond to overload resistance with potential hypertrophy and hyperplasia of muscle fibers. Neural variables impact muscular strength by influencing neuron firing recruitment, motor unit synchronization, coordination, agonist muscle activity, antagonist muscle activity, and inhibiting the muscle protective mechanism (golgi tendon organ).[18] Kyeongbong Lee et al. observed substantial increases in various parameters in an elastic band strengthening group, suggesting its potential use as an assistive device to the knee-ankle complex.[19] Research by Ziwei Qiao et al. indicates that elastic band resistance training enhances upper and lower limb myodynamia and may improve joint range of motion and ligament flexibility. In the current study, similar findings were observed, with elastic band strengthening contributing to improved ligament flexibility and muscle strength, resulting in enhanced Navicular Drop (ND) FPI and muscle strength.[20]

Marwa S. Saleh et al. investigated the impact of backward walking training on foot posture and dynamic balance in flat-footed participants. Incorporating exercises targeting both intrinsic and extrinsic foot muscle groups, they found substantial results in the group that received backward training in addition to other therapies, aligning with findings in the current study(21).The similar findings are found in the current study.(72) As elastic band helps in improving the muscle volume and ligament laxity which further corrects the foot posture considerably, adding elastic band in the exercise protocol improves FPI more as compared to control group.

Poliana Alves de Oliveira et al. conducted a systematic review and meta-analysis on the effects of elastic resistance training in healthy adults, concluding that it is effective in improving functional performance and muscle strength. Consistent with earlier investigations, the current study demonstrated statistically significant improvement in strengthening with the elastic band compared to the control group, contributing to improved foot posture and ND.(22)

In the current study, implementing both elastic band and non-elastic band strengthening exercises for foot muscles showed positive results in both groups. However, the group with elastic band exercise training, targeting both intrinsic and extrinsic foot muscles, exhibited significantly better improvements in ND, FPI, and muscle strength compared to the non-elastic band exercise group. This suggests that the clinical implementation of elastic band strengthening for foot muscles can be effective in improving flexible flat feet and reducing the risk of musculoskeletal disorders in young adults.

CONCLUSION

Both elastic band strengthening exercise and non-elastic band strengthening exercises are therapeutically beneficial in participants with bilateral flexible flat feet, however elastic band strengthening gives added effects to improve navicular drop (ND), foot posture index (FPI) and muscle strength.

Declaration by Authors

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