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EFFECT OF COMPREHENSIVE EXERCISE PROGRAM ON MEDIAL LONGITUDINAL ARCH AND NAVICULAR DROP IN SUBJECTS WITH UNILATERAL FLEXIBLE FLAT FOOT

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ABSTRACT

Background: Flat foot is a condition in which the medial longitudinal arch becomes abnormally low and the navicular drop is abnormal while comparing the normal individual. This will focus on the curative aspect of individuals with unilateral flexible flatfoot.

Objective: The purpose of this study is to evaluate the effect of comprehensive exercise program on medial longitudinal arch and navicular drop in subjects with unilateral flexible flat foot.

Methods: A total of 30 participants divided into two groups as Group A & B each consisting of 15 participants Group A (15 participants) received comprehensive exercise program session 3 times per week for 6 weeks. GROUP B (15 participants) received conventional exercise program sessions three times per week for 6 weeks. Medial longitudinal arch and navicular drop were assessed for pre and post-intervention using a navicular drop test and Medial longitudinal arch angle.

Results: Using unpaired 't' test for comparison of the post-test values of Group A and Group B, In which Navicular drop test shown 't' value of 9.82 and medial longitudinal arch angle shown 't' value of 44.04 respectively.

Conclusion: The study concludes that comprehensive exercise program is more effective than the conventional exercise.

Keywords: Flexible flat foot, Comprehensive exercise, Conventional exercise, Navicular drop, Medial Longitudinal arch angle.

INTRODUCTION:

The human foot is a complex structure which can perform a wide range of tasks. It offers a basis of support when standing. The foot needs to be able to absorb shock and be stable when it strikes and pushes off during locomotion [1]. Three parts comprise the foot's bones: the talus and calcaneus in the hindfoot, the cuboid, navicular, and three cuneiforms in the midfoot, and the metatarsals and phalanges in the forefoot. Three arches are formed by these bones: the transverse arch, the lateral longitudinal arch, and the medial longitudinal arch

[2]. The foot's ability to absorb stress, transfer body weight, propel forward during movement, and serve as a foundation of support depends on the structure and dynamicity of the foot arches. The medial longitudinal arch is taller than the lateral longitudinal arch, and when bearing weight, its curvature may vary to varying degrees [4][5].

Due to the presence of fat, new-born's feet appear flat. When the child begins to walk and the foot begins to take the weight, the arches become noticeable. The foot's arches grow quickly between the ages of two and six, reaching structural maturity between the ages of twelve and thirteen[3][6].When the medial longitudinal arch's curvature is flatter than usual and the entire foot comes into near-complete or total contact with the ground, it is known as pes planus [4]. Flexible flat foot and rigid flat foot are the two types of flat foot. In a flexible flat foot, the medial longitudinal arch is absent in closed kinematic chain (weight-bearing) situations and present in open kinematic chain (non-weight- bearing) conditions. The medial longitudinal arch height is lost in rigid flat feet under both open and closed kinematic chain circumstances. [6]

Children have a high prevalence of flat feet because of ligament laxity, which decreases with age [4]. Between the ages of 2 and 6, 21 to 57% of children have flexible flat feet. In elementary school, the incidence drops to 13–28%. Among those between the ages of 11 and 16, the prevalence is 42%; 23% of them have bilateral flatfeet, and 19% have unilateral flat feet. The frequency is 13.6% among young adults between the ages of 18 and 21, with girls having a slightly higher prevalence (14.4%) than males (12.8%). Four Various researches have reported prevalence in the general adult population ranging from 5 to 14% [7][8].

There are several causes for flat feet, including trauma, external rotation of the hind foot, midfoot laxity, and malfunction of the posterior tibial tendon [9]. The incidence of pain is increased around the lower extremity and the ankle foot complex. There may be difficult in walking and an altered gait pattern. Flat foot is also associated with osteoarthritis, as the posture and motion of the foot and knee are coupled within a closed kinematic chain during most weight bearing activities. Closed chain coupling may link excessive flat foot morphology to excessive internal rotation. [10].

The following are considered risk factors for acquired flat foot: age, obesity, and not wearing shoes when young. Evidence has indicated that abnormal muscle function, either at birth or later in life, is a contributing factor. These effects have an impact on everyday activities, injuries and productivity at work, sports performance, and injury risk [29][30].By eccentrically regulating adduction and internal rotation of the thigh, the gluteus muscles stabilize the hip by counteracting the torque of hip adduction and preserving appropriate leg alignment. Foot pronation results from the internal rotation of the hip joint caused by weakening in the gluteus muscle. Reactivating the gluteal muscles can help restore proper muscular recruitment patterns and improve strength and performance [9].

In order to treat flexible flat foot, other approaches have also been employed. For example, passive supports including foot orthoses, taping, and motion control footwear have been proposed. However, the enhanced foot arches brought about by the strengthening of the intrinsic foot muscles which are frequently recommended by the therapist—provide further benefits of active exercise intervention over passive supports [10].
Comprehensive exercises for flat feet can significantly improve foot function, reduce discomfort, and prevent further complications. By targeting the muscles of the foot, arch, and lower legs, these exercises help to strengthen and realign the foot's structure, promoting better support for the arch. This leads to improved posture, enhanced balance, and decreased pain or fatigue associated with flat feet [21].Strengthening the intrinsic foot muscles can also reduce the risk of conditions like plantar fasciitis and tendonitis, which are common in individuals with flat feet. Over time, regular exercise can improve mobility and overall foot health, leading to a more functional and pain-free lifestyle.

Short foot exercise is a type of sensory motor training that actively shapes the foot's longitudinal and horizontal arches by engaging the intrinsic muscles of the foot [11]. Through enhancing afferent impulses from the bottom of the foot, short foot exercise can enhance the alignment of body segment and the stability of the body when standing. If the short foot exercise is combined with other exercises, the initial phase of sensory- motor training can enhance proprioception and postural stability [12]. Short foot exercise is a training

method used to maintain a medial longitudinal arch by drawing the head of the first metatarsal to the heel without bending or hyperextending the toes [13].
The Navicular Drop Test is a useful tool for assessing the medial longitudinal arch's function for the examination of patients with foot impairment [14]. The perpendicular distance between the floor and the navicular tuberosity was measured with a vernier caliper first in non- weight bearing then in weight-bearing. A distance of >10mm was diagnostic of flexible flat foot [27].

The medial longitudinal arch is constructed from the first metatarsal bone, cuneiforms navicular, talus and calcaneus. It supports the body weight, loaded from the tibia and talus, with soft tissues connecting them. Flat foot represents the collapse of the medial longitudinal arch [26].
The medial longitudinal arch is measured using the medial longitudinal arch angle (MLAA) formed between the line from the medial malleolus to the navicular tuberosity and the line connecting the head of the first metatarsal bone and the navicular tuberosity was measured in degrees [27].

METHODOLOGY

Study Design: Pre-test and Post-test Experimental Study Design.
Participants: The participants included was the age between 18 to 25 years of both the genders, individuals having unilateral foot with navicular drop of >10mm and medial longitudinal arch angle < 130°, whereas the individuals with ankle/foot pain or injuries in the past 6 months, any acute injury or facture of lower limb, presence of neurological signs and congenital deformity of lower limb were excluded.
Intervention: Based on the inclusion criteria and willingness, the individuals were recruited for the study. Further they are divided into 2 groups by simple random sampling method. A clear assessment is done to find the suitable subjects in the study. The study includes 30 individuals - Group A and Group B, each consists of 15 individuals. A clear instruction given to all the individuals who signed up for the study and written consent is obtained from every individual. Prior to the exercise a brief instruction is given to each individual regarding the exercise protocol and beneficial effect of exercise. Following the assessment subjects pretest values were assessed using medial longitudinal arch angle and navicular drop test.

GROUP A

Subjects received a comprehensive exercise program for about 30 minutes. The intervention was performed at three sessions per week for 6 weeks.

SHORT FOOT EXERCISE

- Hallux extension
- Doming
- Lesser toe extension
- Toe spread

GLUTEAL MUSCLE STRENGTHENING

- Hip abduction (side lying)
- Hip extension (prone lying)

Hallux extension

Doming

Lesser toe extension

Toe spread

Hip abduction (side lying)

Hip extension (prone lying)

GROUP B

Subjects received conventional exercise for about 30 minutes. The exercise program was conducted for three sessions per week for 6 weeks.

- Toe raise
- Heel raise
- Eversion
- Inversion

Toe raise

Heel raise

Eversion

Inversion

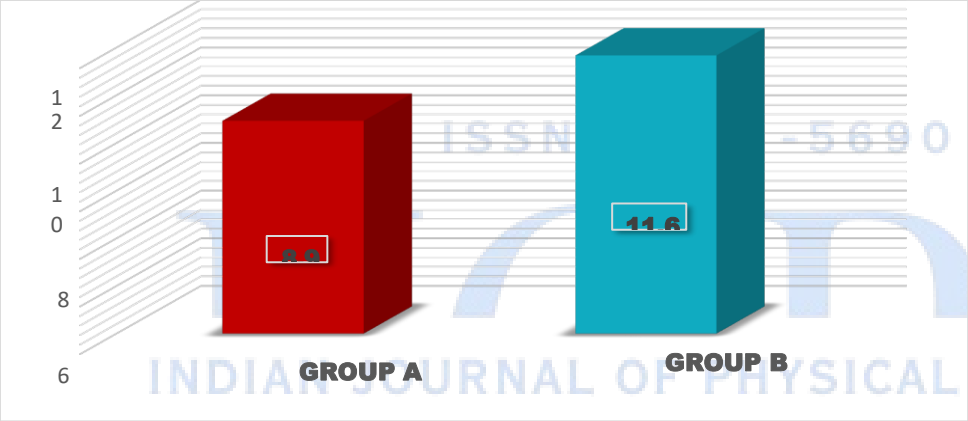
Outcome Measures: Medial Longitudinal Arch Angle and Navicular Drop Test.

Statistical Analysis: Methods used for data analysis

RESULTS

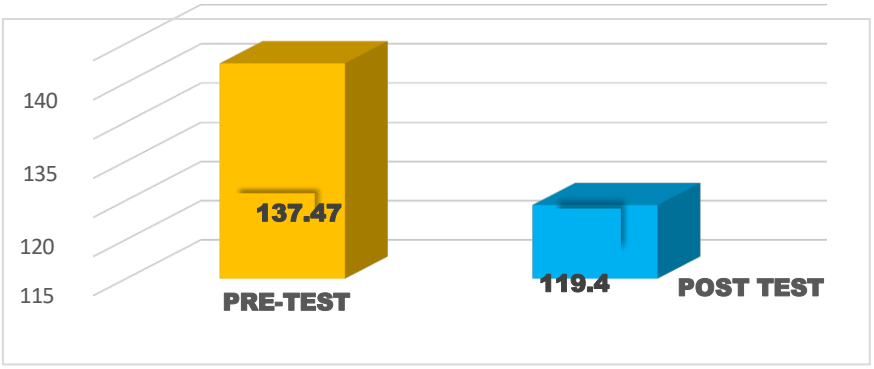
UNPAIRED 't' TEST OF NAVICULAR DROP TEST OF BOTH THE GROUPS

SNO	GROUP	MEAN	MEAN DIFFERENCE	STANDARD DEVIATION	'T' VALUE
1	A	8.93	2.73	0.80	9.82
2	B	11.67		0.72	



UNPAIRED 't' TEST OF MEDIAL LONGITUDINAL ARCH ANGLE OF BOTH THE GROUPS

S.NO	GROUPS	MEAN	MEAN DIFFERENCE	STANDARD DEVIATION	't' VALUE
1	GROUP A	137.47	18.07	1.19	44.04
2	GROUP B	119.40		1.06	



DISCUSSION

Unpaired 't' test was used to calculate the post test values of navicular drop between two groups, Data analysis of this showed with 't' value of 9.82. Unpaired 't' test was used to calculate the post test value of medial longitudinal arch between two groups, Data analysis of this showed with 't' value of 44.04. On comparing the pre-test and post-test values of Group A and Group B, both groups showed improvement, Group A who underwent comprehensive exercise program showed significant improvement on navicular drop height and medial longitudinal arch in subjects with unilateral flat foot. This result rejects all null hypothesis and accepts the alternate hypothesis.

The flat foot deformity had changed the mechanics of the lower limbs up to the pelvis (18). Koh et al stated that the weakness and dysfunction of the hip external rotators can lead to excessive adduction and medial rotation of hip and also the dynamic genu valgum, which can affect the foot pronation. The gluteus maximus, medius and minimus stabilizes the hip by counteracting hip adduction torque and maintaining the proper alignment of leg by eccentric control to adduction and internal rotation of thigh, and externally rotating the alignment of the lower extremity, reducing the foot pronation. Gluteal muscle weakness internally rotates the hip joint and induces foot pronation. Reactivating the gluteal muscles will re-establish correct muscle recruitment patterns and enhance the strength and performance of the gluteal muscles. Hence, gluteal muscle strengthening indirectly strengthens the kinetic chain and help in vanishing the flat foot. Short foot exercises enhance the flexor hallucis brevis muscle, which maintains the medial longitudinal arch during the terminal stance in gaits to maintain foot stability, and the abductor pollicis muscle, which bears the weight and propels the body forward during push-off in gait [11]. Short foot exercise effectively strengthens the intrinsic muscles, such as abductor hallucis, which may play an important role in supporting the Medial longitudinal arch [19]. Intrinsic foot muscles also play an important role in static balance like standing on 1 leg and in adjusting the posture. A study investigated the effects of toe flexion exercise in normal subject and found improvement in walking, running and also in jumping [21]. Another study proved that the activation of abductor hallucis was greater in standing on 1 leg rather than using both legs while standing, with activation patterns being highly correlated with medial postural sway [20].

Lynn et al and Kim et al found that the short foot exercise for 4-5 weeks improved the balance and navicular drop in patients with flexible flat foot [22][11][13]. Lee et al found that intrinsic muscle exercise is given 5days/week for 6 weeks improved the plantar pressure distribution and dynamic balance in adults with flat foot. [23].Conventional exercise program improves medial longitudinal arch and reduced the navicular drop (ie improved). Hence, conventional exercise help in reducing the unilateral flexible flat foot.
The result from the statistical analysis of this study supported that there will be beneficial effect on the subjects treated with comprehensive exercise program than subjects treated with conventional exercise program.

CONCLUSION

This study concluded that there is a significant improvement in both groups, in terms of navicular drop, Group A is more significant than Group B. In terms of Medial longitudinal arch, there is significant improvement in both groups. Group A is more significant than Group B. There will be beneficial effects to the subjects treated with comprehensive exercise program than subjects treated with conventional exercise program.

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