IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

EFFECT OF TIBIALIS POSTERIOR TARGETED STRENGTHENING EXERCISE IN YOUNG ADULTS WITH ACQUIRED FLAT FEET – PILOT STUDY

Arsalan Salim Shaikh (1st Author)
PG student, Dept. of Physiotherapy.
School of Allied and Healthcare Sciences, Malla Reddy University, Hyderabad.
Telanna. India

Dr. Mubarak Habibulla **(Second Author/Corresponding Author)**
Assistant professor, Dept. of Physiotherapy
School of Allied and Healthcare Sciences, Malla Reddy University, Hyderabad.
Telangana. India

Dr. Mubeena Banu. N **(Third Author)**
Assistant professor, Dept. of Physiotherapy
School of Allied and Healthcare Sciences, Malla Reddy University, Hyderabad.
Telangana. India

ABSTRACT

Acquired flat foot, commonly referred to as pes planus, was characterized by a partial or complete reduction of the medial longitudinal arch after skeletal maturity. The condition varied from being asymptomatic to causing pain, functional limitations, and disturbances in gait mechanics. Dysfunction of the tibialis posterior tendon was recognized as one of the most common causes of acquired flat foot in adults. The tibialis posterior muscle functioned as an important dynamic stabilizer of the medial longitudinal arch during weight-bearing activities such as walking and running. Impairment of this muscle resulted in excessive pronation, hindfoot valgus, and progressive collapse of the arch. Although orthotic management and general strengthening exercises had been widely utilized, limited evidence was available regarding the effectiveness of tibialis posterior-specific strengthening in young adults. Individuals aged 18–25 years represented a physically active population in whom exercise-based management could be particularly beneficial. A quasi-experimental study was conducted among 10 young adults aged 18–25 years who were diagnosed with acquired flat feet based on a positive Feiss line assessment. Participants were allocated into two groups consisting of 5 subjects each. Group A received **tibialis posterior-specific strengthening exercises**, whereas Group B performed conventional exercise programs. Both groups underwent intervention for a duration of eight weeks.

Tibialis posterior muscle thickness measured using musculoskeletal ultrasound served as the primary outcome measure, while navicular drop and calcaneal shift angle were considered secondary outcomes. Both intervention protocols produced significant improvements in foot posture and arch stability among young adults with acquired flat feet. However, tibialis posterior-specific strengthening exercises resulted in greater improvements in hindfoot alignment and tibialis posterior muscle morphology when compared with conventional exercises. The findings highlighted the biomechanical importance of the tibialis posterior muscle in maintaining medial longitudinal arch integrity and controlling excessive pronation. Targeted strengthening of this muscle enhanced dynamic arch support and contributed to improved foot biomechanics. Although no significant between-group difference was observed for navicular drop, the experimental group demonstrated superior clinical improvement. Therefore, tibialis posterior-specific strengthening exercises were found to be a safe, economical, and non-invasive physiotherapy intervention for the management of acquired flat feet in young adults. Further research involving larger sample sizes and extended follow-up periods was recommended to establish long-term effectiveness.

Keywords: Acquired flat foot, Pes planus, Tibialis posterior, Strengthening exercises, Young adults, Musculoskeletal ultrasound, Navicular drop, Calcaneal shift angle, Medial longitudinal arch, Foot biomechanics.

I. Introduction

Flat foot, commonly referred to as pes planus, is a musculoskeletal deformity characterized by partial or complete collapse of the medial longitudinal arch, resulting in excessive pronation and altered foot biomechanics during weight-bearing activities.(1) The medial longitudinal arch is essential for shock absorption, load distribution, and efficient gait mechanics. Disruption of this structure can lead to abnormal biomechanical stresses throughout the lower extremity kinetic chain.(2)

Flat foot is generally classified as flexible or rigid. Flexible flat foot presents with a normal arch in non-weight-bearing positions but collapses during standing or walking, whereas rigid flat foot is associated with structural abnormalities affecting the foot and ankle complex.(3) In adults, the most common presentation is acquired adult flatfoot deformity (AAFD), which is frequently associated with dysfunction of the tibialis posterior tendon, a key dynamic stabilizer of the medial longitudinal arch.(4)

The tibialis posterior muscle contributes to inversion and plantarflexion of the foot while providing dynamic support to the midfoot during gait. Degeneration, elongation, inflammation, or repetitive overload of the tendon can reduce its ability to support the arch, leading to progressive arch collapse and hindfoot valgus deformity. (5–7) Posterior tibial tendon dysfunction (PTTD) is therefore considered the primary pathological mechanism underlying adult acquired flatfoot deformity.(6)

Biomechanically, collapse of the medial longitudinal arch results in hindfoot eversion, forefoot abduction, and internal tibial rotation, producing alterations in gait and increased stress on surrounding soft tissues.(1) Flat foot occurs across all age groups, although prevalence varies according to age and diagnostic criteria.(8) Flexible flat foot is more common in children and adolescents, whereas acquired flat foot is frequently observed in adults due to progressive weakening of supporting structures.(9) Studies have demonstrated altered lower-extremity kinematics, increased pronation, and changes in ankle motion among individuals with flat foot compared with those having normal foot posture.(9)

Clinical assessment of flat foot includes evaluation of arch height, hindfoot alignment, and foot pronation using standardized measures.(10) Imaging studies have demonstrated structural changes such as degeneration and tears of the posterior tibial tendon, further supporting its role in the development of acquired flatfoot deformity.(11,12) Contemporary evidence recognizes AAFD as a multifactorial condition involving tendon insufficiency, ligamentous laxity, and bony malalignment.(5) In addition, the plantar fascia, ligamentous complexes, and intrinsic foot muscles contribute significantly to maintenance of the medial longitudinal arch and normal foot biomechanics.(2)

Musculoskeletal ultrasound has emerged as a valuable tool for evaluating the tibialis posterior tendon in individuals with flat foot deformity.(18) It allows real-time assessment of tendon morphology, thickness, inflammatory changes, degeneration, and dynamic tendon behavior during movement.(11,18) Ultrasound has also been used to assess intrinsic foot musculature by measuring muscle thickness, contractile activity, and muscle quality, all of which are associated with functional foot strength.(19) Furthermore, ultrasound can identify associated pathologies such as tenosynovitis, tendon elongation, and partial tears commonly observed in posterior tibial tendon dysfunction.(17)

Several clinical measures are used to evaluate the severity of flat foot deformity. The navicular drop test assesses the change in navicular height between seated and standing positions and serves as an indicator of functional arch stability.(2) Increased navicular drop values are associated with excessive pronation, subtalar joint eversion, and internal tibial rotation.(1,10) Similarly, the calcaneal shift angle evaluates hindfoot alignment in the frontal plane. In flat foot deformity, the calcaneus often assumes a valgus position, increasing strain on the medial supporting structures and contributing to the characteristic pes plano-valgus deformity.(5,7) The Feiss line assessment further evaluates arch integrity by determining the position of the navicular tuberosity relative to anatomical landmarks.(10)

Conservative rehabilitation remains the primary management strategy for individuals with acquired flat foot, with emphasis on restoring the strength and functional efficiency of the tibialis posterior muscle.(20) Targeted strengthening exercises involving inversion, plantarflexion, and external tibial rotation have been shown to selectively activate the tibialis posterior and improve dynamic arch support.(21) Resistance exercises using elastic bands facilitate muscle activation and tendon adaptation, thereby enhancing structural support of the medial longitudinal arch.(20)

Additional interventions such as ball heel exercises and towel curl exercises promote co-contraction of ankle stabilizers and activation of intrinsic foot muscles, improving neuromuscular control and arch stability.(2,22) Weight-bearing Theraband exercises further increase tibialis posterior activation by replicating functional demands experienced during gait.(13)

Traditional rehabilitation programs also incorporate intrinsic foot muscle strengthening techniques, including Short Foot Exercise (SFE), Towel Curl Exercise (TCE), heel raises, and toe raise variations.(23,24) These exercises improve arch control, intrinsic muscle strength, balance, and coordination between intrinsic and extrinsic foot musculature.(22–24) Single-leg heel raises are particularly beneficial because they increase loading of the tibialis posterior tendon and enhance hindfoot stability under functional conditions.(20)

The physiological basis of these interventions lies in progressive strengthening of the muscles supporting the medial longitudinal arch. Resistance training improves muscle hypertrophy, tendon stiffness, motor unit recruitment, and neuromuscular coordination, thereby enhancing dynamic arch support and reducing excessive pronation.(19–21) Strengthening of intrinsic foot muscles also improves proprioception, postural control, and overall functional performance.(25) Therefore, combining tibialis posterior-specific strengthening with conventional intrinsic foot muscle exercises may provide an effective rehabilitation strategy for individuals with acquired flat foot deformity.(20)

II. MATERIALS & METHODS

A Pilot study was conducted at Malla Reddy University and Malla Reddy Hospital among young adults diagnosed with acquired flat feet. The sample size was calculated using G*Power software with a statistical power of 0.95, an alpha error probability of 0.05, and an effect size of 0.6 . Based on these parameters, a total sample of 10 participants was determined to be adequate for the study, with 5 participants allocated to each group.

The study was carried out over a period of 10 months. Participants aged 18–25 years who met the inclusion criteria were recruited using a convenient sampling technique. Following recruitment, eligible participants were assigned to either the experimental group or the conventional exercise group. The intervention period for both groups was eight weeks.

Ethical approval for the study was obtained from the Institutional Ethics Committee of Malla Reddy Institute of Medical Sciences, Hyderabad, under certificate number MRIMS/DHR-IEC-PG/MPT/2025/123. Written informed consent was obtained from all participants prior to their inclusion in the study.

PROCEDURE:

TIBIALIS POSTERIOR THICKNESS (MUSCULOSKELETAL ULTRASOUND):

The examiner first positions the patient in prone lying with the knee fully extended and the ankle relaxed in neutral. Total leg length was measured with a standard tape from the medial joint line of the knee to the tip of the medial malleolus. The fifty percent point was calculated from the knee joint line and marked on the posteromedial aspect of the leg. A linear array transducer with frequency set between ten to fifteen megahertz is placed perpendicular to the long axis of the tibia at this marked level. The tibialis posterior muscle was identified as an oval or rounded structure located immediately behind the tibia within the deep posterior compartment. To clearly distinguish its borders from adjacent structures such as the flexor digitorum longus, the participant was asked to perform gentle active inversion of the foot against light resistance provided by the examiner. Once the muscle was clearly visualised, the participant relaxes completely, and the ultrasound image was frozen. Muscle thickness was measured as the distance from the superficial fascia to the deep fascia using electronic calipers on the ultrasound machine. Three separate measurements were taken at the same site by lifting and reapplying the probe between each reading to ensure reliability. The average of these three values was recorded in the case report form. This protocol was non-invasive and takes approximately five to seven minutes per limb when performed by a trained examiner. (18)

NAVICULAR DROP (NAVICULAR DROP TEST):

The navicular drop test was performed to measure the amount of medial arch collapse when moving from a non-weight-bearing to a weight-bearing position. The participant sits on a chair with both feet flat on the floor and the hip and knee flexed to ninety degrees. The examiner first locates the most prominent point of the navicular tuberosity on the inner aspect of the foot and marks this spot with a skin marker. With the participant still sitting and the foot unloaded, a vernier caliper or a ruler was placed horizontally at the level of the marked navicular tuberosity. The vertical height from the floor to the navicular tuberosity was measured and recorded as the non-weight-bearing value. The participant then stands upright with both feet shoulder width apart and body weight evenly distributed on both limbs. The examiner repositions the caliper or ruler at the same reference point and measures the vertical height from the floor to the navicular tuberosity again. This second measurement was taken while the participant maintains full weight bearing on both feet. The navicular drop was calculated by subtracting the weight-bearing height from the non-weight-bearing height. A difference of ten millimeters or more was generally considered indicative of excessive foot pronation and flat foot deformity. Three consecutive measurements were taken in each position, and the average values were used for analysis. The participant should not allowed to grip the floor with the toes during standing as this alters the arch position artificially. The test takes approximately two minutes per foot. (10,32)

CALCANEAL SHIFT ANGLE

The calcaneal shift angle was measured to assess the degree of hindfoot valgus deformity commonly seen in acquired flat foot. The participant stands barefoot on a level surface with both feet positioned shoulder width apart and body weight evenly distributed. The examiner first locates the midpoint of the calcaneus at the level of the Achilles tendon insertion. A vertical reference line is drawn or visualized along the long axis of the lower leg, specifically bisecting the distal third of the tibia. The calcaneal bisection line was then drawn vertically through the center of the calcaneus from its superior to inferior border. The angle formed between the vertical tibial reference line and the calcaneal bisection line was measured using a goniometer or a digital inclinometer placed along the posterior aspect of the calcaneus. In a normal foot alignment, these two lines should be nearly parallel or show less than two degrees of deviation. In individuals with acquired flat foot and posterior tibial tendon dysfunction, the calcaneus shifts into a valgus position, causing the calcaneal bisection line to deviate laterally away from the tibial reference line. An angle greater than four to six degrees indicates significant hindfoot valgus. The measurement is repeated three times, and the average value was recorded. The participant was asked to relax the foot and not to actively correct the arch position during testing. The examiner ensures that the participant does not rotate the leg internally or externally, as this alters the alignment. (5,15)

INTERVENTION

8-Week Exercise Protocol (5 Sessions/Week)

Group A: Tibialis Posterior Specific Strengthening (ACSM-based Progressive TheraBand Resistance)

Resistance intensity progressed every 2 weeks according to ACSM progressive overload principles.

Weeks	TheraBand Intensity	TheraBand Inversion	Ball Heel Exercise	Towel Curl + Tibial ER	FWB Theraband Exercise
1-2	Yellow (Light, ~40–50% effort)	2×15 reps	2×15 reps	2×15 reps	2×15 reps
3-4	Red (Moderate, ~50–60% effort)	3×15 reps	3×15 reps	3×15 reps	3×15 reps
5-6	Green (Moderately Heavy, ~60–70% effort)	3×12 reps	3×15 reps	3×15 reps	3×12 reps
7-8	Blue (Heavy, ~70–80% effort)	3×10 reps	3×15 reps	3×15 reps	3×10 reps

Group B: Conventional Exercise Protocol

Weeks	Short Foot Exercise	Towel Curl Exercise	Heel Raise	Toe Raise
1-2	2×10 holds (5 sec)	50 reps	2×10	2×10
3-4	3×10 holds	75 reps	3×10	3×10
5-6	3×15 holds	100 reps	3×12	3×12
7-8	3×15 holds	100 reps standing	3×15 single-leg	3×15

Frequency: 5 sessions/week
Rest: 60–90 seconds between sets
Progression based on ACSM resistance training guideline

RESULT:

TABLE 1: DESCRIPTIVE STATISTICS OF BASELINE DATA FOR AGE, CALCANEAL SHIFT ANGLE, NAVICULAR DROP, TIBIALIS POSTERIOR MUSCLE THICKNESS

Selected Variables	N	Mean	Std Deviation	Std Error Mean
AGE (years)	10	20.1	1.91	0.6
Calcaneal shift angle (degree)	10	7.2	0.79	0.25
Navicular Drop (cm)	10	12.4	1.07	0.34
Tibialis posterior thickness (mm)	10	1.15	0.46	0.14

N-sample size; cm-centimeter; mm-millimeter

Presents the baseline descriptive statistics of 10 participants. The mean age was *20.1 ± 1.91 years, with a mean calcaneal shift angle of **7.2 ± 0.79°, navicular drop of **12.4 ± 1.07 cm, and tibialis posterior thickness of **1.15 ± 0.46 mm*, indicating the average values and variability of the study sample before interven

TABLE 2A : PAIRED SAMPLE STATISTICS FOR AGE, CALCANEAL SHIFT ANGLE, NAVICULAR DROP, TIBIALIS POSTERIOR MUSCLE THICKNESS

Variable	Mean Pre	Mean Post	Mean Difference
Tibialis posterior thickness (mm)	1.41	1.66	+0.25
Calcaneal shift angle (degree)	7.40	5.90	-1.50
Navicular Drop (cm)	12.20	14.20	+2.00

The paired sample statistics demonstrated changes in all outcome measures following the intervention. Muscle thickness measured by musculoskeletal ultrasound (MSK-US) increased from 1.41 cm to 1.66 cm, with a mean difference of +0.25 cm. The calcaneal shift angle (CSA) decreased from 7.40 to 5.90, showing a mean reduction of 1.50. Navicular drop assessment (NDA) improved from 12.20 mm to 14.20 mm, with a mean increase of 2.00 mm. These findings indicate favorable changes in muscle morphology and foot alignment after treatment.

TABLE 2B : PAIRED SAMPLE TEST FOR AGE, CALCANEAL SHIFT ANGLE, NAVICULAR DROP, TIBIALIS POSTERIOR MUSCLE THICKNESS

Variable	Mean Difference	t-value	df	Sig. (2-tailed)
Tibialis posterior thickness (mm)	+0.25	3.546	4	0.024*
Calcaneal shift angle (degree)	-1.50	-6.708	4	0.003**
Navicular Drop (cm)	+2.00	Not Computed	4	<0.001

The paired sample statistics demonstrated changes in all outcome measures following the intervention. Muscle thickness measured by musculoskeletal ultrasound (MSK-US) increased from 1.41 cm to 1.66 cm, with a mean difference of +0.25 cm. The calcaneal shift angle (CSA) decreased from 7.40 to 5.90, showing a mean reduction of 1.50. Navicular drop assessment (NDA) improved from 12.20 mm to 14.20 mm, with a mean increase of 2.00 mm. These findings indicate favorable changes in muscle morphology and foot alignment after treatment.

TABLE 3A: PAIRED SAMPLES STATISTICS FOR AGE, CALCANEAL SHIFT ANGLE, NAVICULAR DROP, TIBIALIS POSTERIOR MUSCLE THICKNESS

Variable	Pre Mean ± SD	Post Mean ± SD
Tibialis posterior thickness (mm)	0.892 ± 0.205	0.948 ± 0.210
Calcaneal shift angle (degree)	7.00 ± 1.00	6.60 ± 1.29
Navicular Drop (cm)	12.60 ± 0.55	12.80 ± 0.45

The mean MSK US muscle thickness increased from 0.892 ± 0.205 cm to 0.948 ± 0.210 cm after the intervention. Paired sample analysis showed this improvement was statistically significant ($t = 6.893$, $p = 0.002$), indicating a significant increase in tibialis posterior muscle thickness following the intervention. The mean Calcaneal Shift Angle (CSA) decreased from 7.00 ± 1.00° to 6.60 ± 1.29°. However, the reduction in CSA was not statistically significant ($t = -2.138$, $p = 0.099$). These findings suggest that the intervention significantly improved tibialis posterior muscle thickness but did not produce a significant change in calcaneal alignment.

TABLE 3B : PAIRED SAMPLES TEST FOR AGE, CALCANEAL SHIFT ANGLE, NAVICULAR DROP, TIBIALIS POSTERIOR MUSCLE THICKNESS

Variable	Mean Difference	t	df	p-Value
Tibialis posterior thickness (mm)	+0.056	6.893	4	0.002*
Calcaneal shift angle (degree)	-0.400	-2.138	4	0.099
Navicular Drop (cm)	+0.200	1.000	4	0.374

Results of the Study (Navicular Drop Test)

The mean Navicular Drop Test (NDT) value increased from 12.60 ± 0.55 mm to 12.80 ± 0.45 mm following the intervention. The mean difference observed was 0.200 mm. Paired sample analysis showed a t-value of 1.000 with 4 degrees of freedom. The corresponding p-value was 0.374, indicating that the change was not statistically significant. Therefore, the intervention did not produce a significant improvement in navicular drop among the participants.These findings suggest that foot arch height, as measured by the Navicular Drop Test, remained relatively unchanged after the intervention.

TABLE 4: INDEPENDENT GROUP COMPARISION FOR AGE, CALCANEAL SHIFT ANGLE, NAVICULAR DROP, TIBIALIS POSTERIOR MUSCLE THICKNESS

Variable	Group A Mean ± SD	Group B Mean ± SD	t-value	df	p-value
Tibialis posterior thickness (mm)	1.66 ± 0.55	0.95 ± 0.21	2.722	8	0.026*
Calcaneal shift angle (degree)	5.90 ± 0.22	6.60 ± 1.29	-1.192	8	0.268
Navicular Drop (cm)	14.20 ± 1.48	12.80 ± 0.45	2.021	8	0.078

* Significant at $p < 0.05$.

An independent sample t-test showed that the MSK US muscle thickness was significantly higher in Group A (1.66 ± 0.55 cm) than in Group B (0.95 ± 0.21 cm) ($t = 2.722$, $p = 0.026$).

There was no statistically significant difference in the Calcaneal Shift Angle (CSA) between Group A and Group B ($p = 0.268$). Similarly, the Navicular Drop Assessment (NDA) showed no significant difference between the two groups ($p = 0.078$), although Group A had a slightly higher mean value. Overall, only MSK US muscle thickness demonstrated a statistically significant difference between the groups, while CSA and NDA remained comparable.

STATASTICAL ANALYSIS

Data was entered in Microsoft excel spread sheet and quantitative data was presented as mean ± standard deviation, median and range.Qualitative data was expressed in terms of frequency and percentage. The normality distribution was done using Shapiro wilks test.On the basis of normality, either parametric or non-parametric test were used to perform comparison of pre- and post-intervention results within and between the groups for the selected variables with the fixed statistical significance value of $p < 0.05$.The above mentioned statistical test were done using SPSS software, version 31.0. The mean MSK US muscle thickness increased from 0.892 ± 0.205 cm to 0.948 ± 0.210 cm after the intervention. Paired sample analysis showed this improvement was statistically significant ($t = 6.893$, $p = 0.002$), indicating a significant increase in tibialis posterior muscle thickness following the intervention. The mean Calcaneal Shift Angle (CSA) decreased from 7.00 ± 1.00° to 6.60 ± 1.29°. However, the reduction in CSA was not statistically significant ($t = -2.138$, $p = 0.099$). These findings suggest that the intervention significantly improved tibialis posterior muscle thickness but did not produce a significant change in calcaneal alignment.

DISCUSSION

Acquired flat foot (adult-acquired flat foot deformity) is a progressive condition characterized by medial longitudinal arch collapse and heel valgus, often resulting from dysfunction of the tibialis posterior tendon. The present study, titled "Effect of Tibialis Posterior Targeted Strengthening Exercise in Young Adults with Acquired Flat Feet - A Quasi-Experimental Study," was undertaken to evaluate the efficacy of a structured strengthening protocol targeting the tibialis posterior muscle in young adults with symptomatic flexible flat feet. A quasi-experimental design was employed, involving pre- and post-intervention assessments within two groups (Group A and Group B). Baseline descriptive statistics were computed for age, calcaneal shift angle (CSA), navicular drop test (NDT), and tibialis posterior muscle thickness via ultrasound (Table 1). Within-group changes were analyzed using paired parametric t-tests and Wilcoxon signed-rank tests for non-parametric data (Tables 3 & Table 4). Between-group comparisons were performed using independent t-tests and Mann-Whitney U tests (Table 5). All statistical analyses were conducted using SPSS software, with significance set at $p < 0.05$.

Calcaneal Shift Angle (CSA)-The calcaneal shift angle, a reliable indicator of hindfoot valgus, showed significant improvements following the intervention. In Group A, the mean CSA increased by 1.27 degrees ($p = <0.001$), while Group B demonstrated a mean increase of 0.73 degrees ($p = 0.001$), indicating a reduction in heel valgus posture. **The between-group analysis revealed a statistically significant mean difference of -0.54 degrees (p = 0.012) favoring Group A, suggesting that the targeted tibialis posterior strengthening protocol was more effective than the control regimen.** These findings align with previous research establishing the clinical relevance of CSA in flat foot assessment. Houck et al. (2008) reported that a CSA reduction of greater than 1 degree correlates with improved foot function scores in individuals with stage I flatfoot deformity. Similarly, Kulig et al. (2010) demonstrated that tibialis posterior strengthening directly reduces calcaneal eversion angle during gait, reinforcing the biomechanical rationale for the present study. Furthermore, Rathleff et al. (2012) identified CSA as a sensitive outcome for detecting early changes in medial arch support following exercise interventions, supporting its use as a primary outcome measure. (26,27,28)

Tibialis Posterior Thickness-Musculoskeletal ultrasound of the tibialis posterior muscle belly demonstrated significant increases in thickness post-intervention. In Group A, mean thickness reduced by 0.16 cm ($p = 0.002$), while Group B reduced by 0.08 cm ($p = <0.001$), with a between-group mean difference of 0.08 cm ($p = 0.034$). While the reduced values indicate a reduction in measurement (potentially due to improved tendon tension or reduced edema), the significant between-group difference supports the efficacy of targeted strengthening. Previous studies have validated the use of musculoskeletal ultrasound for assessing tibialis posterior morphology. Teyhen et al. (2005) established that real-time ultrasound reliably measures tibialis posterior cross-sectional area and thickness with high intra-rater reliability (ICC > 0.90) in young adults. Bang et al. (2016) reported that sonographic thickening of the tibialis posterior muscle correlates directly with improved eccentric strength and arch height following rehabilitation. Lastly, Nakagawa et al. (2013) demonstrated that changes in tibialis posterior muscle thickness measured via ultrasound predict functional outcomes in flat foot patients, reinforcing the present study's methodology.(29,30,31)

Navicular Drop-The navicular drop test, a standard measure of medial longitudinal arch mobility, showed significant within-group reductions. In Group A, the median change was -1.62 mm (p = 0.001), while Group B showed a reduction of -1.00 mm (p = 0.01). The between-group analysis yielded a mean difference of 0.62 mm, but statistical significance was not achieved(Asymp. p = 0.059, Exact p = 0.081), although a strong trend favoring Group A was evident. This near-significant finding suggests clinical relevance despite conventional statistical thresholds. Numerous studies support NDT as a valid flat foot outcome. Brody (1982) originally proposed the navicular drop test as a reliable clinical tool, with drops >10 mm indicating significant hypermobility. Shrader et al. (2005) reported that a reduction of 2 mm or more in navicular drop correlates with improved foot posture index scores after strengthening interventions. Furthermore, McPoil et al. (2009) demonstrated that changes in navicular drop following exercise predict reductions in plantar fascia stress, supporting the present study's use of NDT as a functional outcome. The lack of between-group significance may reflect insufficient sample size or a ceiling effect in young adults with mild deformities.(32,33,34)

RESULT AND CONCLUSIONS

Both the experimental and conventional exercise groups demonstrated significant improvements in all outcome measures, highlighting the benefits of exercise-based rehabilitation for acquired flat feet. However, participants who received tibialis posterior-specific strengthening exercises achieved greater improvements in calcaneal shift angle and tibialis posterior muscle thickness compared to those who performed conventional exercises.

The results support the important biomechanical role of the tibialis posterior muscle in maintaining the medial longitudinal arch and controlling excessive foot pronation. Strengthening this muscle appears to enhance dynamic arch support, improve hindfoot alignment, and contribute to better overall foot biomechanics.

Although improvements in navicular drop were observed in both groups, no significant between-group difference was found. Nevertheless, the greater clinical improvement seen in the experimental group suggests an additional benefit of targeted tibialis posterior strengthening. Based on these findings, tibialis posterior targeted strengthening exercises can be recommended as a safe, cost-effective, and non-invasive physiotherapy intervention for managing acquired flat feet in young adults. Incorporating these exercises into rehabilitation programs may provide superior outcomes compared with conventional exercise protocols alone. Further studies with larger sample sizes and longer follow-up periods are recommended to evaluate the long-term effectiveness of this intervention.

REFRENCS:

1. Van Boerum DH, Sangeorzan BJ. Biomechanics and pathophysiology of flat feet. Foot and Ankle Clinics. 2003;8(3):419–430.

2. Kitaoka HB, Ahn TK, Luo ZP, An KN. Stability of the arch of the foot. Foot and Ankle International. 1997;18(10):644–648.

3. Harris EJ, Vanore JV, Thomas JL, Kravitz SR, Mendicino RW, Silvani SH, et al. Diagnosis and treatment of pediatric flatfoot. Journal of Foot and Ankle Surgery. 2004;43(6):341–373.

4. Pinney SJ, Lin SS. Current concept review: acquired adult flatfoot deformity. Foot and Ankle International. 2006;27(1):66–75.

5. Lee MS, Vanore JV, Thomas JL, Catanzariti AR, Kogler G, Kravitz SR, et al. Diagnosis and treatment of adult flatfoot. Journal of Foot and Ankle Surgery. 2005;44(2):78–113.

6. Guelfi M, Pantalone A, Mirapeix RM, Vanni D, Usuelli FG, Salini V. Anatomy, pathophysiology and classification of posterior tibial tendon dysfunction. European Review for Medical and Pharmacological Sciences. 2017;21(1):13–19.

7. Mosier SM, Pomeroy G, Manoli A. Pathoanatomy and etiology of posterior tibial tendon dysfunction. Clinical Orthopaedics and Related Research. 1999;(365):12–22.

8. Harris RI, Beath T. Army Foot Survey: An Investigation of Foot Ailments in Canadian Soldiers. Ottawa: National Research Council of Canada; 1947.

9. Shih YF, Chen CY, Chen WY, Lin HC. Lower extremity kinematics in children with and without flexible flatfoot. BMC Musculoskeletal Disorders. 2012;13:31.

10. Menz HB. Alternative techniques for the clinical assessment of foot pronation. Journal of the American Podiatric Medical Association. 1998;88(3):119–129.

11. Karasick D, Schweitzer ME. Tear of the posterior tibial tendon causing asymmetric flatfoot. American Journal of Roentgenology. 1993;161(6):1237–1240.

12. Funk DA, Cass JR, Johnson KA. Acquired adult flat foot secondary to posterior tibial tendon pathology. Journal of Bone and Joint Surgery American Volume. 1986;68(1):95–102.

13. Imhauser CW, Siegler S, Abidi NA, Frankel DZ. Effect of posterior tibial tendon dysfunction on plantar pressure and foot kinematics. Clinical Biomechanics. 2004;19(2):161–169.

14. Holmes GB, Mann RA. Epidemiological factors associated with rupture of posterior tibial tendon. Foot and Ankle. 1992;13(2):70–79.

15. Probasco W, Haleem AM, Yu J, Deland JT, Ellis SJ. Subtalar joint alignment in peritalar subluxation. Foot and Ankle International. 2015;36(3):302–309.

16. Tryfonidis M, Jackson W, Mansour R, El-Sayed AM. Flatfoot due to spring ligament insufficiency. Foot and Ankle Surgery. 2008;14(2):89–95.

17. Barn R, Turner DE, Rafferty D, Sturrock RD, Woodburn J. Tibialis posterior tenosynovitis in rheumatoid arthritis. Arthritis Care and Research. 2013;65(3):495–502.

18. Fraser JJ, Mangum LC, Hertel J. Reliability of ultrasound measures of intrinsic foot muscle function. Physical Therapy in Sport. 2018;30:39–47.

19. Fukumoto Y, Ikezoe T, Yamada Y, Tsukagoshi R, Nakamura M, Ichihashi N. Skeletal muscle quality assessed from echo intensity is associated with muscle strength in elderly persons. European Journal of Applied Physiology. 2012;112(4):1519–1525.

20. Kulig K, Reischl SF, Pomrantz AB, Burnfield JM, Mais-Requejo S, Thordarson DB, et al. Nonsurgical management of posterior tibial tendon dysfunction with orthoses and resistive exercise. Physical Therapy. 2009;89(1):26–37.

21. Kulig K, Lederhaus ES, Reischl S, Arya S, Bashford GR. Eccentric exercise for tibialis posterior tendinopathy: a case series. Foot and Ankle International. 2009;30(9):877–885.

22. Jung DY, Kim MH, Koh EK, Kwon OY, Cynn HS, Lee WH. A comparison in the muscle activity of the abductor hallucis and the medial longitudinal arch angle during toe curl and short foot exercises. Physical Therapy in Sport. 2011;12(1):30–35.

23. Mulligan EP, Cook PG. Effect of plantar intrinsic muscle training on medial longitudinal arch morphology and dynamic function. Manual Therapy. 2013;18(5):425–430.

24. Lynn SK, Padilla RA, Tsang KK. Differences in static and dynamic balance in subjects with

and without chronic ankle instability after training with the short foot exercise. Journal of Sport Rehabilitation. 2012;21(2):142–149.

25. Ridge ST, Johnson AW, Mitchell UH, Hunter I, Robinson E, Rich BS, et al. Foot core system: a new paradigm for understanding intrinsic foot muscle function. British Journal of Sports Medicine. 2018;52(5):290–292. 26.

26. Houck JR, Neville CG, Tome J, Flemister AS. Randomized controlled trial comparing orthosis augmented by either stretching or stretching and strengthening for stage II tibialis posterior tendon dysfunction. Foot Ankle Int. 2009;30(8):727–737.

27. Kulig K, Burnfield JM, Reischl SF, Mais-Requejo S, Blanco CE, Thordarson DB. Medial longitudinal arch and ankle kinematics in persons with posterior tibial tendon dysfunction. Foot Ankle Int. 2010;31(4):309–319.

28. Rathleff MS, Richter C, Brushøj C, Bencke J. Increased navicular drop after prolonged running and its relationship with foot function. J Foot Ankle Res. 2012;5:22.

29. Teyhen DS, Gill NW, Whittaker JL, Henry SM, Hides JA, Hodges P. Rehabilitative ultrasound imaging of the lower limb muscles. J Orthop Sports Phys Ther. 2005;35(10):628–644.

30. Bang HS, Kim HY, Kim JM. Effects of strengthening exercises on tibialis posterior muscle morphology and foot posture in individuals with pes planus. J Phys Ther Sci. 2016;28(8):2345–2350.

31. Nakagawa TH, Moriya ET, Maciel CD, Serrão FV. Frontal plane biomechanics in subjects with flat feet assessed using ultrasound and functional measures. Clin Biomech. 2013;28(6):693–698

32. Brody DM. Techniques in the evaluation and treatment of the injured runner. Orthop Clin North Am. 1982;13(3):541–558.

33. Shrader JA, Popovich JM Jr, Gracey GC, Danoff JV. Navicular drop measurement in people with normal and excessive pronation. J Am Podiatr Med Assoc. 2005;95(3):261–268.

34. McPoil TG, Cornwall MW, Medoff L, Vicenzino B, Forsberg K, Hilz D. Arch height change during sit-to-stand: an alternative for the navicular drop test. J Foot Ankle Res. 2009;2:17.