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To Compare Effectiveness of Stirrup Muscle Exercises and Short Foot Exercise on Foot Posture Index and Tibial Torsion in Children with Moderate Flexible Flat Foot: A Comparative Study

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Abstract

Objectives

To study effectiveness of stirrup muscles strengthening on foot posture index and tibial torsion, To study effectiveness of short foot exercise on foot posture index and tibial torsion and To compare effectiveness of stirrup muscles strengthening and short foot exercises on foot posture index and tibial torsion in children with moderate flexible flat foot within duration of 4 weeks.

Methods

Subjects were selected on the basis of inclusion and exclusion criteria Subjects were explained about the study before starting the treatment. Consent was taken by the subjects. Subjects were assessed for flexible flat foot and tibial torsion with foot posture index and thigh foot angle respectively. Subject were divided into group A & group B by random allocation. Group A subjects were treated with short foot exercise. Group B subject were treated with stirrup muscle strengthening for 4 weeks. 3 time per week. After 4 weeks subjects were assessed for flexible flat foot and tibial torsion.

Results

50 participants were included in the study .Paired T test were done within groups .The result obtained for short foot exercise on foot posture index suggests significance as 'P' value obtained was (<0.0001)and t value for left foot was 22.3925 and for right was 20.7169 this suggests that there is significant effect of short foot exercise on flat foot.

The result obtained for short foot exercise on thigh foot angle suggests significance as 'P' value obtained was (<0.0001)and t value for left leg was 8.8196 and for right leg was 8.5704 this suggests that there is significant effect of short foot exercise on lateral tibial torsion.

The result obtained for stirrup muscle strengthening on foot posture index suggests significance as 'P' value obtained was (<0.0001) and t value for left foot was10.3815 and for right foot was 9.7143. this suggests that there is significant effect of stirrup muscle strengthening on flat foot.The result obtained for stirrup muscle strengthening on thigh foot angle suggests significance as 'P' value obtained was (<0.0001) and t value for left leg was5.6569 and for right leg was 5.7287 . This suggests there is significant effect of stirrup muscle strengthening on lateral tibial torsion.

A comparison of foot posture index between the groups produce significant difference: for left foot is -2.00 and for right foot is -1.64

Which shows short foot exercise has a clinical advantage than stirrup muscle strengthening for improving flat foot in adolescents a comparison of thigh foot angle between groups produce a difference : For left leg is -1.24 and for right leg is -1.08

Which shows none of the exercise has a clinical advantage than other for improving tibial torsion in adolescents

Conclusion

This study shows that short foot exercise is effective than stirrup muscle exercise on foot posture index in children with moderate flexible flat foot. But there is no difference in effectiveness of stirrup muscles exercise and short foot exercise on thigh foot angle in children with moderate flexible flat foot.

Keywords

Stirrup muscles, short foot exercise, foot posture index, tibial torsion, thigh foot angle

Flat Foot

It is characterized by defect in the absorption mechanism of foot during weight bearing due to collapse of mainly medial longitudinal arch. [(1)]Normal arches dampen the effect of weight bearing forces and superimposed rotational motions. Components of flat foot are: loss of medial longitudinal arch, hindfoot valgus , medial talar prominence, pronation of foot.

The clinical appearance of a flatfoot is more complicated than the simple depression or absence of a longitudinal arch. There is a straight or convex plantar-medial border of the foot. The lateral border is straight or concave. The mid-foot sags and touches the ground in weight-bearing . The foot appears externally rotated in relation to the leg and the weight-bearing axis of the lower extremity passes medial to the mid-axis of the hindfoot. The hindfoot is in valgus alignment . [(2)]

Flexible Flat Foot

In flexible flatfoot, medial longitudinal arch of the foot collapses in various degrees during weight-bearing . However during raising up one's body on tiptoe (tiptoe test) foot arch forms again. When

weight-bearing forces on feet are relieved this arch can be observed. [3]

Flexible flatfoot is a normal foot shape that is present in most infants and many adults. The arch elevates spontaneously in most children during the first decade of life. There is no evidence that a longitudinal arch can be created in a child's foot by any external forces or devices.

Flexible flatfoot with a short Achilles tendon, in contrast to simple flexible flatfoot, is known to cause pain and disability in some adolescents and adults. [2] greater intrinsic muscle activity is required to stabilize the transverse tarsal and subtalar joints in a flatfooted individual than in one with an average height arch, this might be expected to lead to foot fatigue and pain. Fortunately, foot fatigue and pain seem to occur only in some flatfooted individuals. [5]

greater intrinsic muscle activity is required to stabilize the transverse tarsal and subtalar joints in a flatfooted individual than in one with an average height arch, this might be expected to lead to foot fatigue and pain. Fortunately, foot fatigue and pain seem to occur only in some flatfooted individuals. [5]

Classification of Flexible Flat Foot: (3)

Mild - arch is slightly impressed but still visible

Moderate - longitudinal arch is not visible in stance

Severe – medial border of foot is concave with head of talus presenting on plantar aspect of foot immediately below and anterior to medial malleolus

Tibial Torsion

External tibial torsion is defined as twist of tibia laterally in relation to femur. Lateral tibial torsion increases from 5.5 degrees at 18 months of age to 11.2 degrees at 6 years of age.[6] The mean tibial torsion range without impairments is between 16 degrees-50 degrees. [7]External tibial torsion commonly affects older children or adolescents.

Stirrup Muscles

Tibial is anterior and peroneus longus

The tendons of tibial is anterior and peroneus longus together form a sling (stirrup) which keeps the middle of the foot pulled upwards, thus supporting the longitudinal arches. [1] Both muscles attach at the same point (first metatarsal, medial cuneiform) so help to lift mid foot.

Intrinsic Plantar Musculature

Muscles of Plantar Layer I group of the intrinsic plantar musculature have attachments into the plantar fascia. By supporting the plantar fascia, they help to support the arch . They are the flexor digitorum brevis, abductor hallucis, and abductor digiti minimi pedis. [8]

Short Foot Exercise

Short-foot exercise (SFE) is a widely used balance training intervention that has been developed recently to improve ankle proprioception and to strengthen the intrinsic foot muscles (IFM) so as to elevate and support the medial longitudinal arch (MLA) of the foot and improve dynamic standing balance . SFE is performed by attempting to pull the head of the first metatarsal toward the calcaneus, without curling the toes. [9]

Foot Posture Index

Recently, a six-item criterion reference tool (the Foot Posture Index, or FPI) was developed in response to a requirement for a quick, easy and reliable method for measuring foot position in a variety of clinical settings . The FPI consists of six validated, criterion-based observations of the rear-foot and forefoot of a subject standing in a relaxed position. The rearfoot is assessed via palpation of the

head of the talus, observation of the curves above and below the lateral malleoli and the extent of the inversion/eversion of the calcaneus. The observations of the forefoot consist of assessing the bulge in the region of the talo-navicular joint, the congruence of the medial longitudinal arch and the extent of abduction/adduction of the forefoot on the rearfoot. [10]

Thigh Foot Angle

Tibial version or torsion is the degree of rotation of the tibia along its long axis from the knee to the ankle. It is measured with the patient prone with his or her knees flexed to 90°. It is the angle between the line of axis of the thigh and the line along axis of foot. A normal TFA is 10-15° of external rotation. By convention, external rotation values are positive. [11]

As arch collapses, foot will not be able to dampens rotational force. Hence flexible flat foot results in external tibial torsion. [12]Ankle joint in which axis is positioned more laterally in transverse plane tibial torsion is seen to be increased. [12]

Materials Used

Pen, Paper, Goniometer, Foot posture index, Consent form

Method

Subjects were selected on the basis of inclusion and exclusion criteria. Subjects were explained about the study before starting the treatment.Consent was taken by the subjects. Subjects were assessed for flexible flat foot and tibial torsion with foot posture index and thigh foot angle respectively. Subject were divided into group A & group B by random allocation. Group A subjects were treated with short foot exercise. Group B subject were treated with stirrup muscle strengthening for 4 weeks. 3 time per week. After 4 weeks subjects were assessed for flexible flat foot and tibial torsion.

Inclusion Criteria

Individuals age: 7 to 14 years, individuals with moderate flexible flat foot, external tibial torsion more than 15 degrees, Both males and females, Individuals with grade 4 strength of Tibial is anterior and peroneus longus.

Exclusion Criteria

Rigid flat foot, recent foot injury or surgery from 8 -12 weeks, acute and severe flexible flatfoot

Protocol

Short Foot Exercise [15]

SFE was implemented as sensory-motor training for improvement in the flatfoot of the experimental group. Before the intervention, the researcher demonstrated the short foot exercises while giving verbal instructions. Thereafter, each subject was instructed to sit on a height-adjustable chair and bend the hip joint, knee joints, and ankle joints to 90° and a towel was placed below the feet. Thereafter, the subject was instructed to pull the head of the first metatarsal bone toward the heel without bending the toes and maintain the state for 20 sec to form the MLA.

During the exercise, to prevent the forefoot and the heel from being lifted off the ground and smoothly induce the flexion of the head of the metatarsal bone, the measurer gently held the instep and the heel. The posture was maintained for 10 sec followed by 5 sec and this process was implemented for 30 minutes per time, three times per week for a total of four weeks.

Stirrup Muscles Strengthening

Tibialis Anterior Strengthening [16]:

patient position - long sitting/supine

Procedure

Place rolled towel under the distal leg to elevate the heel slightly.Tie an elastic band or tubing to the foot end of the bed (or other object) and place a loop over the dorsum of foot. Ask patient to take foot towards him against resistance.

- Hold- 10 sec
- Repetitions- 10
- Sets- 3
- 3 time per week.

Tibialis anterior strengthening

Peroneus Longus Strengthening [10]:

Patient position: supine/long sitting

Procedure

Place a loop of elastic tubing around both feet and ask patient to take foot outward (evert).Instruct the patient to keep the knees still and just turn the foot outward not allowing the thigh and leg to abduct or externally rotate.

- Hold- 10 sec
- Repetitions- 10 repetitions
- sets- 3
- 3 times per week

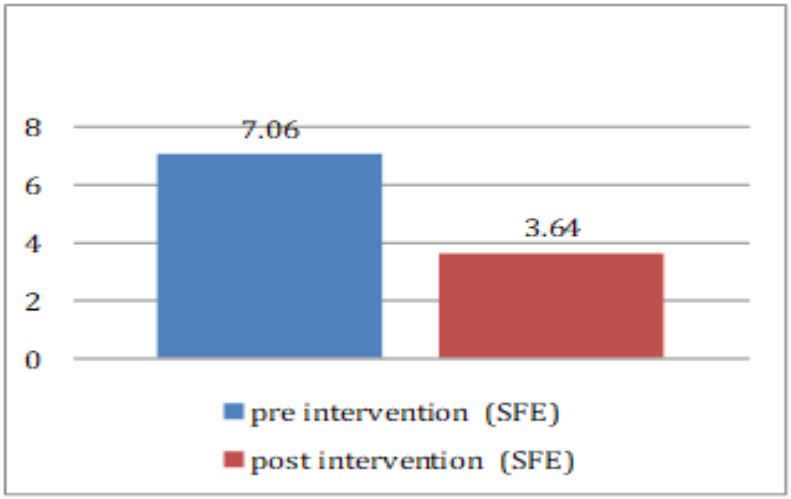
Peroneus longus strengthening

Data Analysis

Intra-Group Comparisons

Short Foot Exercise Paired 'T' Test Result

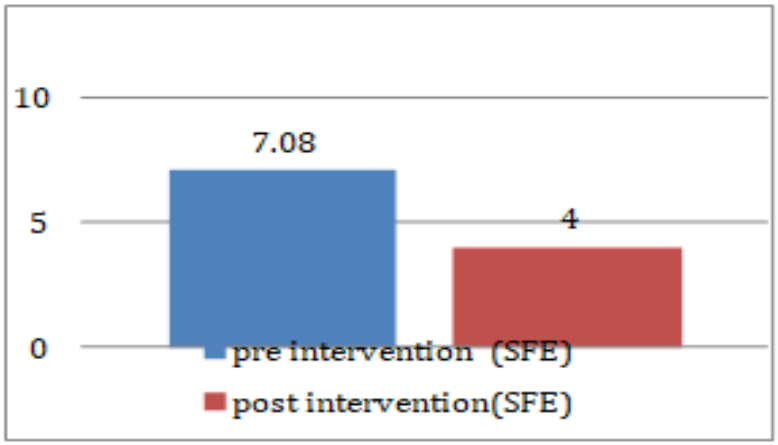
Graph 1- comparison of pre and post values of foot posture index (left foot)



	SHORT FOOT EXERCISE (L) mean	P value	T value	result
FOOT POSTURE INDEX	Pre post	<0.0001	22.3925	Extremely significant
	7.08 8.64			

Short Foot Exercise Paired 'T' Test Result

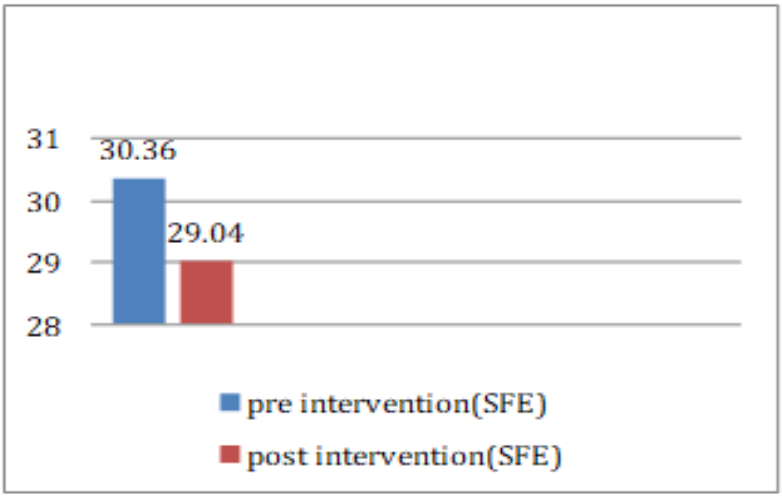
Graph 2 - comparison of pre and post values of foot posture index (right foot)



	SHORT FOOT EXERCISE (R) mean	P value	T value	result
FOOT POSTURE INDEX	Pre post	<0.0001	20.7169	Extremely significant
	7.08 4.0			

Short Foot Exercise Paired 'T' Test Result

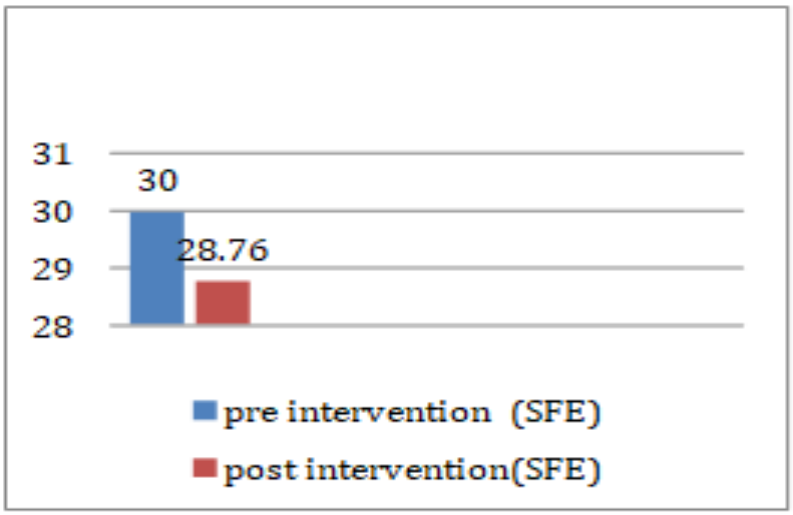
Graph 3 - comparison of pre and post values of thigh foot angle (left leg)



	SHORT FOOT EXERCISE(L) mean	P valu e	T value	result
THIGH FOOT ANGL E	Pre post 30.36 29.04	<0.00 01	8.8196	Extrem ely signific ant

Short Foot Exercise Paired 'T' Test Result

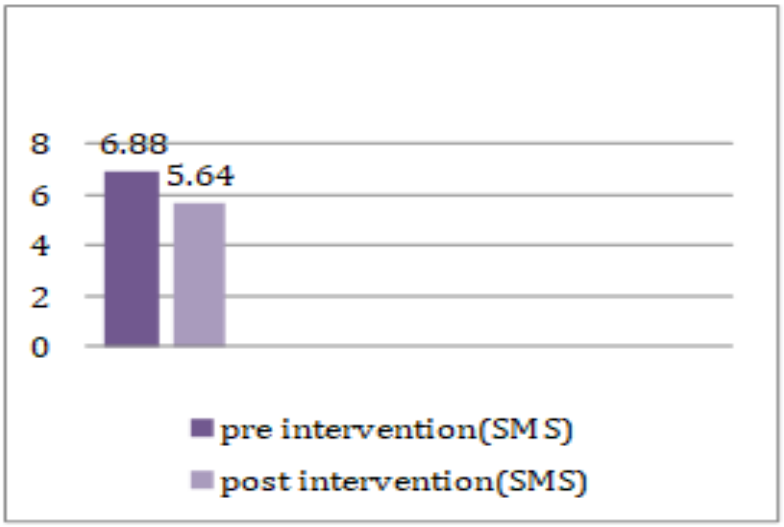
Graph 4 - comparison of pre and post values of thigh foot angle (right leg)



	SHORT FOOT EXERCISE (R) mean	P value	T value	result
THIGH FOOT ANGLE	Pre post 30.0 28.76	<0.0001	8.5704	Extremely significant

Stirrup Muscle Strengthening Paired 'T' test Result

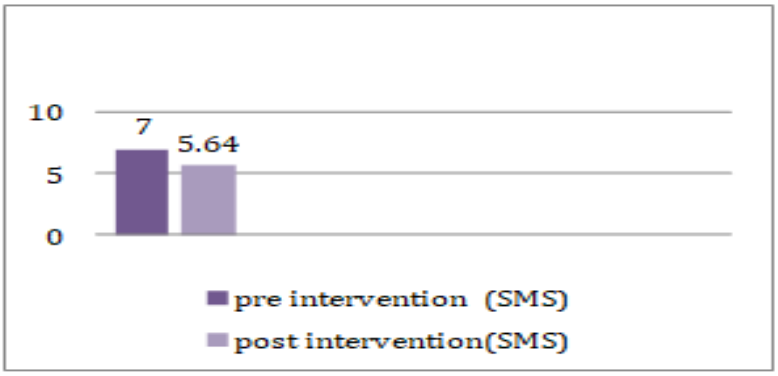
Graph 5 - comparison of pre and post values of foot posture index (left foot)



	STIRRUP MUSCLES STRENGTHENING (L) mean	P value	T value	result
FOOT POSTURE INDEX	Pre post 6.88 5.64	<0.0001	10.3815	Extremely significant

Stirrup Muscle Strengthening Paired 'T' Test Result

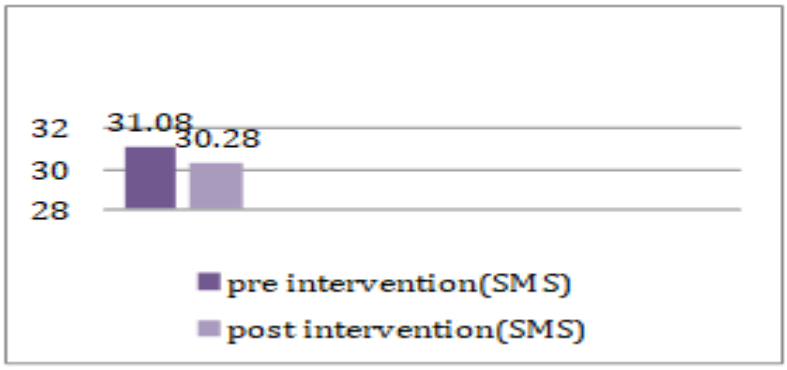
Graph 6 - comparison of pre and post values of foot posture index (right foot)



	STIRRUP MUSCLE STRENGTHENING (R) mean	P value	T value	result
FOOT POSTURE INDEX	Pre post 7.0 5.64	<0.0001	9.7143	Extremely significant

Stirrup Muscle Strengthening Paired 'T' Test Result

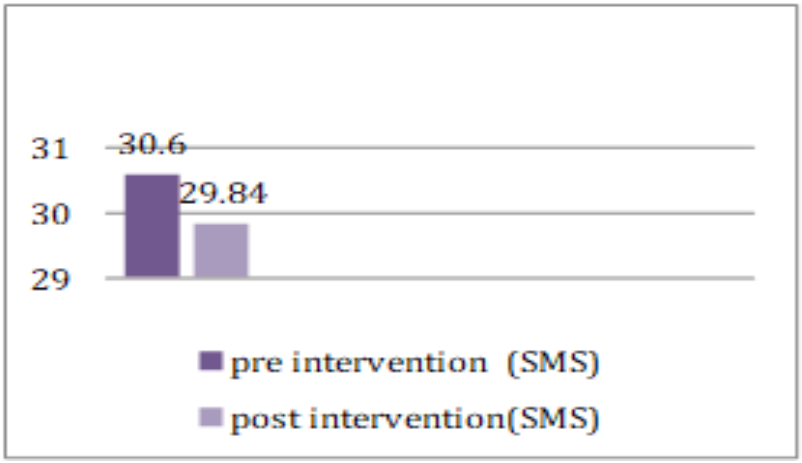
Graph 7 - comparison of pre and post values of thigh foot angle(left leg)



	STIRRUP MUSCLE STRENGTHENING (L) mean	P value	T value	result
THIGH FOOT ANGLE	Pre post 31.08 30.28	<0.0001	5.6569	Extremely significant

Stirrup Muscle Strengthening Paired T' Test Result

Graph 8 - comparison of pre and post values of thigh foot angle(right leg)

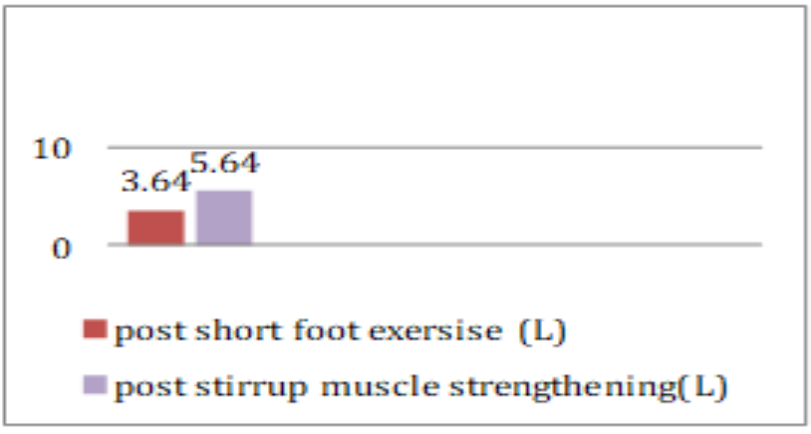


	STIRRUP MUSCLE STRENGTHENING (R) mean	P value	T value	result
THIGH FOOT ANGLE	Pre post 30. 6 29.84	<0.0001	5.7287	Extremely significant

Inter – Group comparison

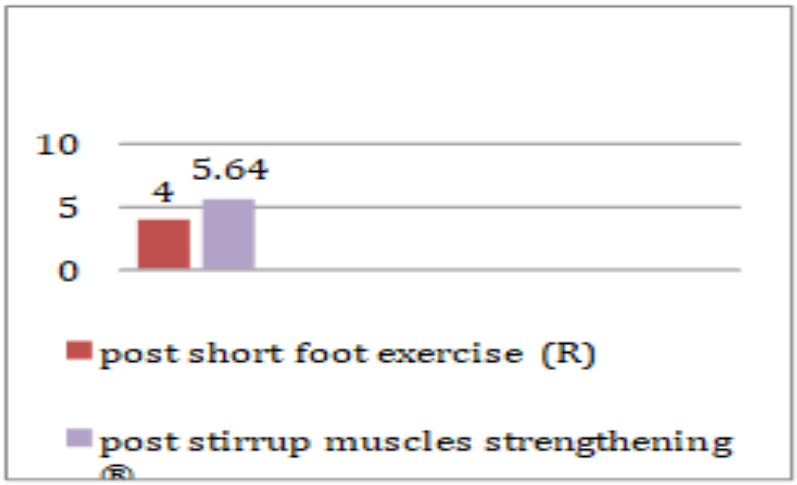
Post and Post values analysis results done using unpaired t-test:

Graph 9 - comparison of post and post values of short foot exercise and stirrup muscles strengthening on foot posture index (left foot)



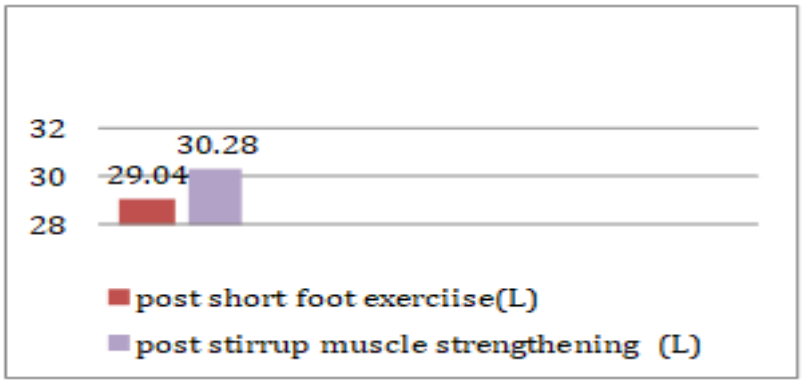
	SHORT FOOT EXERCISE-STIRRUP MUSCLE STRENGTHENING		P value	T value	result
FOOT POSTURE INDEX	Post short foot exercise	Post Stirrup muscle strengthening	<0.0001	8.2199	Extremely significant
	3.64	5.64			

Graph 10 - Comparison of post and post values of short foot exercise and stirrup muscles strengthening on foot posture index (right foot)



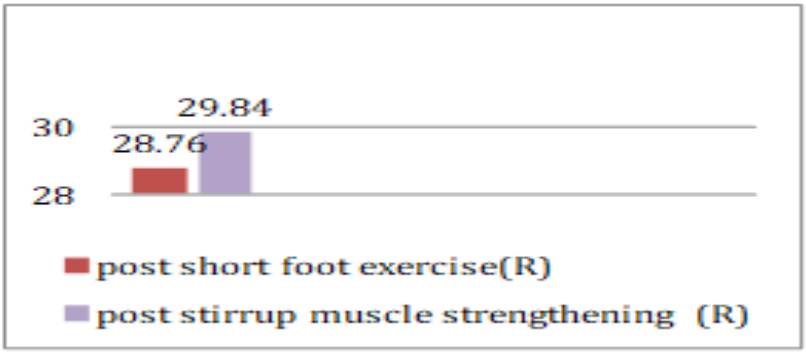
	SHORT FOOT EXERCISE-STIRRUP MUSCLE STRENGTHENING (R) mean		p value	t value	result
FOOT POSTURE INDEX	Post short foot exercise	Post Stirr up muscle strengthening	<0.0001	6.2164	Extremely significant
	4	5.64			

Graph 11- comparison of post and post values of short foot exercise and stirrup muscles strengthening on thigh foot angle(left foot)



	SHORT FOOT EXERCISE-STIRRUP MUSCLE STRENGTHENING(L) mean		P value	T value	result
THIGH FOOT ANGLE	Post short foot exercise	Post Stirrup muscle strengthening	0.3293	0.9855	Not significant
	29.04	30.28			

Graph 12: comparison of post and post values of short foot exercise and stirrup muscles strengthening on thigh foot angle(right foot)



	SHORT FOOT EXERCISE-STIRRUP MUSCLE STRENGTHENING (R)mean		P value	T value	result
THIGH FOOT ANGLE	Post short foot exercise	Post Stirrup muscle strengthening	0.3828	0.8809	Not significant
	28.76	29.84			

Result

50 participants were included in the study. Paired T test were done within groups .The result obtained for short foot exercise on foot posture index suggests significance as 'P' value obtained was (<0.0001)and t value for left foot was 22.3925 and for right was 20.7169 this suggests that there is significant effect of short foot exercise on flat foot. The result obtained for short foot exercise on thigh foot angle suggests significance as 'P' value obtained was (<0.0001)and t value for left leg was 8.8196 and for right leg was 8.5704 this suggests that there is significant effect of short foot exercise on lateral tibial torsion. The result obtained for stirrup muscle strengthening on foot posture index suggests significance as 'P' value obtained was (<0.0001) and t value for left foot was10.3815 and for right foot was 9.7143. this suggests that there is significant effect of stirrup muscle strengthening on flat foot.The result obtained for stirrup muscle strengthening on thigh foot angle suggests significance as 'P' value obtained was (<0.0001) and t value for left leg was5.6569 and for right leg was 5.7287 . This suggests that there is significant effect of stirrup muscle strengthening on lateral tibial torsion.A comparison of foot posture index between the groups produce significant difference: for left foot is- 2.00 and for right foot is -1.64. Which shows short foot exercise has a clinical advantage than stirrup muscle strengthening for improving flat foot in adolescents. a comparison of thigh foot angle between groups produce a difference : For left leg is -1.24 and for right leg is -1.08. Which shows none of the exercise has a clinical advantage than other for improving tibial torsion in adolescents.

Discussion

This study was intended to compare effectiveness of stirrup muscle strengthening and short foot exercise on foot posture index and tibial torsion in children with moderate flexible flat foot. The study was conducted on children between 7-14 years for 4 weeks. Outcome measures used were- foot posture index-[The FPI demonstrated moderate reliability, with an ICC of 0.61 (95% CI, 0.27-0.81)] [17]

Minoo Patel, MBBS, PhD, MS, FRACS; Chief Editor: Thomas M DeBerardino, MD states that The Foot Posture Index assessment is quick and simple to perform and allows a multiple segment, multiple plane evaluation that offers some advantages over existing clinical measures of foot posture.[11]thigh foot angle- Inter-rater Reliability: 0.25, Intra-rater Reliability: 0.70 (0.55-0.85) , Pearson Correlation Coefficient: TFA- [CT-trans 0.11] [CT-posterior 0.16*] [12] Flatfoot with tibial torsion is common among young children and adolescents (prevalence rate of flexible flat foot among adolescents is 17.1%) [13]. greater intrinsic muscle activity is required to stabilize the transverse tarsal and subtalar joints in a flatfooted individual than in one with an average height arch, this might be expected to lead to foot fatigue and pain. Fortunately, foot fatigue and pain seem to occur only in some flatfooted individuals. [5] In case of flat foot, pronated state of heel is maintained, the talus bone is moved to the inside leading to disappearance of medial longitudinal arch, which results in early fatigue of intrinsic muscles and pain due to compensating actions of intrinsic muscles. [19]Intrinsic muscles of foot have attachments into the planter fascia . By supporting plantar fascia, they help to support arch. [8]Short-foot exercise (SFE) is a widely used balance training intervention that has been developed recently

to improve ankle proprioception and to strengthen the intrinsic foot muscles (IFM) so as to elevate and support the medial longitudinal arch (MLA) of the foot and improve dynamic standing balance . SFE is performed by attempting to pull the head of the first metatarsal toward the calcaneus, without curling the toes. [9]

Synder et al. presented short foot as the most positive method among methods of correcting flat foot. [19]The tendons of tibialis anterior and peroneus longus together form a sling (stirrup) which keeps the middle of the foot pulled upwards, thus supporting the longitudinal arches. [1] Both muscles attach at the same point (first metatarsal, medial cuneiform) so help to lift mid foot. Strengthening these muscles helps to lift medial arch.Therefore this study compared the effectiveness of short foot exercise and stirrup muscles strengthening on flat foot using foot posture index for pre and post assessment in adolescents by the end of 4 weeks. As arch collapses, foot will not be able to dampens rotational force. [12]

Akcali, O., Tiner, M., & Ozaksoy, D. (2000) states that abnormal external tibial torsion may affect the foot deformity and this can change the benign nature of the flexible flatfoot.At the ankle dorsiflexion refers to a motion of the head of talus upwards while body of talus moves posteriorly in the mortise. plantarflexion is the opposite motion because of lower position of fibular malleolus, axis of the ankle is inclined down on the lateral side. Average angle is 14degrees. [12]*Stiehl* used a simple hinged model – when the foot is weight bearing ankle plantarflexion causes tibia-fibula to move laterally as well as rotate laterally, the opposite occurs during weight bearing dorsiflexion. [12]When ankle is plantarflexed – it is pronated and adducted. So in flexible flatfoot, ankle lies in pronated position in weight bearing which causes tibia to rotates laterally causing excessive lateral tibial torsion. [12]Therefore this study compared effectiveness of short foot exercise and stirrup muscle strengthening on tibial torsion using thigh foot angle for pre and post assessment by the end of 4 weeks.In the present study it was shown that short foot exercise was more effective than stirrup muscle strengthening on flat foot but there was no significant difference on tibial torsion.

Conclusion

This study shows that short foot exercise is effective than stirrup muscle exercise on foot posture index in children with moderate flexible flat foot. But there is no difference in effectiveness of stirrup muscles exercise and short foot exercise on thigh foot angle in children with moderate flexible flat foot.

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