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Effect of Gluteus Maximus and Abductor Hallucis Muscle Strengthening on Balance in Pediatric Over Pronated Foot

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ABSTRACT

Background: Maintaining upright posture and balance is essential for all bipedal activities. Central nervous system in conjunction to peripheral nervous system, sensory system and neuromuscular system maintains the postural balance. The lower extremity kinetic chain plays a vital role in maintaining balance. Flat foot is one most common lower extremity malalignment. Abductor hallucis and gluteus maximus muscles are reported to control flatfoot. The aim of this study was to assess the effects of Gluteus maximus and Abductor hallucis muscle strengthening on balance in school going children with pronated foot.
Material and Method: 40 healthy school going children of 7-10 years with either gender were selected on the basis of inclusion and exclusion criteria. Foot posture index and Pediatric berg balance (PBS) score were recorded prior and post exercise. Gluteus maximus and Abductor hallucis muscle strength training were prescribed for 5 days a week for 5 weeks. All variables were assessed post 5 weeks.
Result: After the prescribed period of exercises, it became apparent that Foot FPI and PBS value scored significantly higher when analyzed using the paired t test at $p \leq 0.05$.
Conclusion: Strengthening of Gluteus maximus and Abductor hallucis muscle has significant effect in improving balance in school going children with over pronated foot.

Keywords: Flat Foot, Postural Balance, pediatric, Strength Training, Posture,

INTRODUCTION

Balance plays an important role in maintaining upright posture. Central Nervous system receive and integrate the inputs from vestibular system, visual spatial perception, musculoskeletal and neuromuscular system to maintain the balance.[1] Diminished afferent feedback or lack in the strength and mechanical stability of any joint in the lower extremity kinetic chain may lead to postural imbalance.[3] At distal end of kinetic chain, human foot occupies only 5% of human body weight and plays an important role in activity of daily living by supporting body weight and locomotion. Foot muscles, ligaments, plantar fascia and the arches are involved in protection, bearing load, shock absorption, maintaining stability and balance during standing and walking.[4,5] The arch of foot develops around 2 to 6 years of age and become mature around 12 to 13 years of age.[6] Foot intrinsic muscles are recognized to support medial longitudinal arch. Many studies have

identified abductor hallucis longus muscles as prime stabilizer of medial longitudinal arch and its role in controlling foot over pronation. Weak abductor hallucis is one of the causes of over pronated foot.[7.] Medial longitudinal arch (MLA) height is more than lateral longitudinal arch, which flattens during locomotion and weight bearing. When curvature of MLA flats out entirely, and entire sole touches the ground known as flat foot. It has two components, sagging of arch and heel valgus.[8,9] The terms "flatfoot" and "foot pronation" are often used interchangeably. Foot pronation is a combination of eversion, dorsiflexion and abduction of the foot.[10] Among 2 to 6 years, high prevalence of flat foot is found, which decreases with age. Flat foot is one of the most common causes of pediatric-orthopedic visit as the parents are concerned. In India the incidence of flat foot in school children is reported to be 18.26%.[10,11] Excessive foot pronation has been associated with lower extremity malalignment. The pronation at subtalar joint creates valgus and internal rotation at the knee joint. Due to closed kinetic chain, femur is believed to follow tibia in internal rotation. Studies have found strong relation between excessive internal rotation of hip with weak gluteal maximus muscle. Flat foot produces biomechanical stress, causing a compensatory internal rotation of the tibia or femur and abnormal patellofemoral mechanism.[11] In flat foot, the load on medial arch increases to 17% whereas only 4 % load falls in medial side of normal foot.[12] Thus resulting in abnormal kinetic chain stresses on pelvis and spine and may lead to pain, fatigue and uneven distribution of pressure which subsequently leads to slow walking speed and may result in reduced function, decrease in absorption of impact and loss of postural balance.[13]Various methods of assessment of Pediatric flat foot has been reported including simple examination of the footprints, radiographic measure of the angles, observational tests, or the navicular drop. Foot Posture index 6 is a reliable and valid tool to assess poor pronation in pediatric population.[14] Pediatric berg balance scale is one of reliable and valid scale for assessment of postural balance in pediatric population [15] There is sufficient evidence in the literature supporting the use of custom-made medial arch support, taping, gluteal muscles and abductor hallucis muscle strengthening exercises for the treatment of flat foot. But limited evidences are available on combined effect of Gluteus maximus and abductor hallucis muscle strength training on flat foot. The aim of this study is to find the effectiveness of Gluteus maximus and abductor hallucis muscle strengthening on postural balance in school children with flat foot.

MATERIALS AND METHODS

Pre and post experimental study design was conducted. As the study involved human subjects, the ethical clearance was obtained from the ethical committee of the institution as per the ethical guidelines of bio medical research on human subjects. 40 school going children in age group of 7 to 10 years, of either gender with Foot Posture index value more than 6 were included in the study from residential apartments in Hormavu, Bangalore. The subjects were informed about the procedure and an informed consent was obtained from the parents. Subjects who had pain, any structural deformities of spine or lower extremity, neuromuscular disorders, history of fracture of lower limb, visual, speech and hearing impairments were excluded. Prior to intervention, the baseline measurement of outcome measures was recorded.

For Foot Posture Index 6, the subjects were instructed to stand still barefoot with the arms by the side and looking straight in the relaxed stance position with double limb support and the following six items were measured. Talar head palpation, symmetry of supra and infra lateral malleolar curvature, inversion/eversion of the

calcaneus, prominence in the region of talus-scaphoid joint, height of the medial longitudinal arch, and abduction/adduction of the forefoot. The FPI 6 ranges from -12 (highly supinated) to +12 (highly pronated).[16]

Pediatric Berg balance scale was used to assess the postural balance. Fourteen tasks were performed in given sequence. Each task was scored between 0 to 4 on completion. 0 if subject required maximum assistance to complete the task, 4 was given if a participant could perform the task without supervision. Each participant was scored after completion of all 14 tasks and score out of 56 was calculated and tabulated. A stool of appropriate height, stopwatch, an inch tape, a step stool six inches in height, chalkboard eraser, ruler and two child-size footprints were used for testing[17] (fig-1).

A total 5 weeks exercise protocol was designed comprising short foot exercise and gluteus muscle strength training. Before the intervention, demonstration of short foot exercises was given to all the participants. The subject was asked to sit comfortably on a chair with hip, knee and ankle joint flexion at 90 degrees. Below the feet, one towel was placed and the subjects were asked to pull the first metatarsal bone toward heel without flexing the toes (fig-2). This position was held for 20 sec.[18]

Gluteus maximus strength training was done in prone lying position with knee flexion (PHEKF). The subjects were asked to maintain knee in 90-degree flexion and hip at 30 degrees of abduction. The subject was asked to move the hip away from plinth while the examiner stabilized the pelvis. (Fig-3)[19] These exercises were performed for 20 repetitions in single session for 5 days a week and continues till 4 weeks. They were followed by proper warm-up and cool down. At the end of fifth week, PBS score and Foot Posture Index 6 were recorded and this was considered as post-test data. Pre and post-test values were taken for statistical analysis.

STATISTICAL ANALYSIS

Descriptive and inferential statistical analysis has been carried out in the present study. Outcome measurement was measured and presented as mean ± SD. The data was analyzed by using 't' test to find significance of interventions used within group.

RESULTS

All the results are shown in tabular as well as graphical format to visualize the statistically significant difference more clearly. The p values less than 0.05 are considered to be statistically significant. All the hypothesis was formulated using two-tailed alternatives against each null hypothesis.

The data were analyzed using the independent "t" test to find the significance. The Results were found to be significant with independent "t" test at $p<0.05$ with the calculated "t" value as 11.926 for Foot Posture Index and "t" value 4.833 for the Pediatric berg balance scale.

Table -1: Mean and S.D of height, weight

	N	Mean	Std. Deviation
Weight	40	23.0098	4.72302
Height	40	1.2583	0.10700

40 participants based on inclusion criteria were included in the study with Mean age 23.0098 SD 4.7, Mean height 1.2583, SD 0.107

Table -2: Mean, SD, and pre and post comparison of Foot posture index

FPI	Mean	SD	Average difference	t-Value	p-Value	Result
PRE	7.2683	1.07295				
POST	6.4878	1.12076	0.78049	11.926	.0001	P<0.05

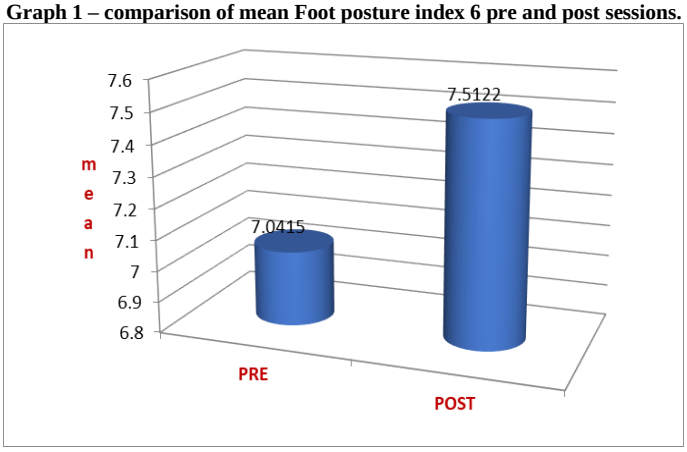
Post 4 weeks of intervention significant difference (P<0.05) was recorded in FPI 6 value with 't' value 11.926.

Table -3 Mean, SD, pre and post comparison of PBS

PBS	Mean	SD	Average difference	t-Value	p-Value	Result
PRE	52.8293	1.94811				
POST	53.3902	1.73029	0.56098	4.833	.0001	P<0.05

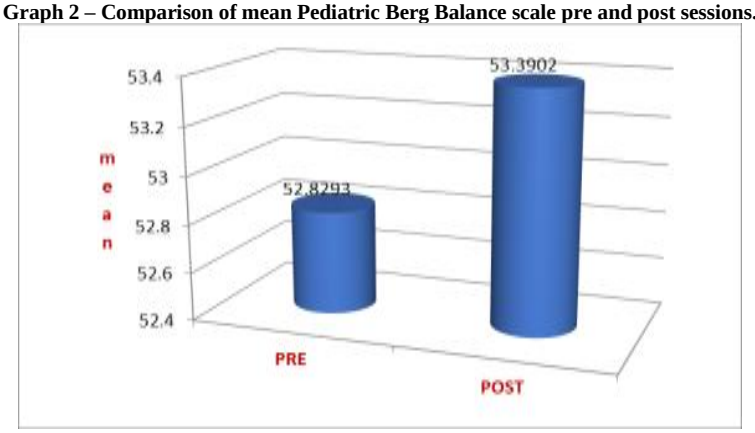
Post 4 weeks of intervention significant difference (P <.05) was recorded in Pediatric Berg Balance scale value with t value 4.833

Graph 1 – comparison of mean Foot posture index 6 pre and post sessions.



Post 4 weeks of intervention significant difference (P<0.05) was recorded in FPI 6 value

Graph 2 – Comparison of mean Pediatric Berg Balance scale pre and post sessions.



Post 4 weeks of intervention significant difference (P<0.05) was recorded in FPI 6 value

DISCUSSION

The purpose of this study was to examine the effectiveness of gluteus maximus and abductor hallucis muscle strength training on postural balance in pediatric with flat foot. 40 participants were selected for the study. Pre intervention FPI 6 and Pediatric berg balances scores were recorded. All the participants underwent 4 weeks of gluteus maximus and abductor hallucis muscle strength training. Post intervention values of FPI 6 and PBS were recorded again. The statistical analysis showed considerable significant difference in independent "t" test at p<0.05 with the calculated "t" value as 11.926 for Foot Posture Index and "t" value 4.833 for the Pediatric berg balance scale. Hence, the result supports the aim of the study.

Intrinsic muscles, mainly abductor hallucis, maintains the center of pressure and supports the medial longitudinal arch. Fatigue in intrinsic muscles is associated with medial shift of centre of pressure and lack of balance. Moon et al in 2014, has documented the effects of short foot exercises on improvement in anteroposterior and medial lateral stability and improvement in centre of pressure leads to improve limit of stability.[20] Janda et al in 1996 all has reported similar findings and possible mechanism behind the similar finding.[21] SFE increase cutaneous afferent stimulation at the bottom of at the foot and stimulate the proprioceptors at thereby increasing afferent stimulation and consequently, improving stability and voluntary muscle activities. [22] findings of this study shows a positive effect of SFE in improvement of toe grip strength and balance in school going children with flatfoot.

At proximal part of Lower extremity kinetic chain, Gluteal muscles play an import role to control hip abduction and internal rotation of thigh by contracting

eccentrically. Strengthening of gluteus muscles improve abduction torque and re-establish correct muscle activation torque and improves lower kinetic chain excessive internal rotation and over pronation of foot [23].goo et al 2016, examines the effects of gluteus maximus and abductor hallucis muscle on navicular drop. The navicular drop improved significantly more in subjects who performed gluteus maximus and abductor hallucis strength training than abductor hallucis strength training alone.[24,25]

Suggestions & Further Recommendations
This study was done on asymptomatic subjects with flat foot, further studies can be carried out on symptomatic over flat foot. Different exercise protocols can be recruited for further study. Other measures like electromyography can be used to assess the muscle strength.

CONCLUSION

Based on the outcome of the final inferential statistical analysis, it was concluded that Gluteus maximus and abductor hallucis muscles strength training is effective in improving postural balance in paediatric over pronated foot.

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Conflict of Interest: None

Source of Funding: None

Ethical Approval: Approved

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