Efficacy of jumping rope for young age students in relation with bilateral flat foot

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ABSTRACT

Introduction and Aim: Arches of the foot normally develop by the age of 5 years or 6 years, if there is an absence of development of arch it leads to the condition called flat foot or pes planus. Flat foot may be congenital or acquired. It can be treated by various exercises, modalities, proper footwear, jumping, etc., This study aims to find the effect of jumping rope in normalizing the arch.

Materials and Methods: 40 patients with bilateral flat feet were selected according to the inclusion and exclusion criteria. The selected subjects were randomly assigned into two groups using the lottery method. Group A was treated with jumping rope barefoot and group B was treated with conventional exercises of the foot.

Results: From the statistical analysis made with the quantitative data revealed a statistically significant difference between the groups.

Conclusion: The study concluded that group with skipping barefoot showed a higher level of a positive outcome in terms of normalizing the arch and improving the functional activities of the lower limb.

Keywords: Flatfoot; navicular drop test; conventional exercises of the foot; skipping; barefoot.

INTRODUCTION

Arches of the foot are the important structures of the foot which helps to maintain a upright posture and acts as a lever, propels the body forward, and helps in various activities such as walking, running, jumping, etc. The arches of the foot was classified into longitudinal and transverse arches of the foot. The longitudinal arch is further classified into medial and lateral. The medial longitudinal arch is more mobile and helps to identify whether the foot is flat or not. The medial longitudinal arch is maintained by various structures such as ends, summit, and pillar. The heads of the first, second, and third metatarsals form the anterior end. The posterior end is formed by the medial tubercle of the calcaneum. The keystone is the talus. The summit is formed by the superior articular surface of the body of the talus. The talus, navicular, and cuneiform bones form the pillar. Normally the medial longitudinal arch is elevated 15-18 mm from the surface, if it is significantly reduced then it is said to be flatfoot (1).

The flatfoot is derived from the collapse of the medial longitudinal arch, which is usually the flatfoot is divided into flexible flatfoot and acquired flatfoot. The flatfoot for each patient is different from one another. The flatfoot should be differentiated from the secondary causes, which can develop as pathological consequences. The flexible flatfoot can be divided into rigid flatfoot. Normally the Flexible flatfoot is due to the collapse of the medial longitudinal arch; however, the arch can be observed when the weight-bearing forces are relived. If the arch is not observed even after relieving the weight-bearing forces, then the flatfoot is said to be rigid flatfoot (2). Adult acquired flatfoot deformity, which usually affects the middle-aged individuals, results in foot pain, malalignment, and loss of function. The adult acquired flatfoot deformity is usually due to the degeneration of posterior tibialis tendon, which normally helps to maintain the talonavicular joint at the apex of the three arches of the foot. The adult acquired flatfoot deformity is initially flexible, later it leads to rigid. Tendon dysfunction commonly leads to secondary damage to the ligaments such as spring and talocalcaneal and associated with injury to the deltoid ligament, plantar fascia, and soft tissue structures. Adult acquired flatfoot deformity may also lead to gait dysfunction, due to the change in shape and function of the foot, as the foot could not able to accommodate to various phases of gait. Single limb heel rise is considered the functional diagnostic test for the adult acquired flatfoot deformity. The inability to perform a single-limb heel-rise is considered a positive functional diagnostic test for the adult acquired flatfoot deformity. Dysfunction of the foot may leads to the imbalance in the forces that tend to flatten the arch, and it may lead to the collapse of the longitudinal arch.

The dysfunction usually results in the arch closing its normal structural support, thus altering its shape. As there is an increase in the effects of the triceps surae or an increase in the individual's bodyweight will lead to the flattening of the arch. Many factors contribute to an acquired flatfoot deformity some of them are excessive tension in the triceps surae, obesity, and posterior tibialis tendon dysfunction or ligamentous laxity within the spring ligament, plantar fascia or other supporting plantar ligaments. Adult acquired flatfoot deformity arises from a combination of too much force and too little support for the arch (3-5). Adult acquired flatfoot deformity that results from the loss of dynamic and static supportive structures of the arch leads to the collapse of a medial longitudinal arch (6). Biomechanical stress over the plantar fascia and spring ligament considers being less than the stress over the posterior tibialis tendon. However, it cannot maintain the plantar arch by itself. Both the tibialis posterior tendon and spring ligament act in reducing the hindfoot pronation, while the plantar fascia is that the main tissue that forestalls arch elongation. Achilles tendon action increases plantar tissue stress. Adult acquired flatfoot deformity is graded from 1 to 111 by Johnson and Strom classification system. In 1997, Myerson added the fourth grade in the classification system. Stage I disease characteristically presents with posterior tibial tendon tenosynovitis with no arch collapse. Patients with stage II adult acquired flatfoot will have foot collapse and can be unable to perform a single-leg heel rise. Stage II is further classified into Stage II a and II b. Stage II a is foot collapse with valgus deformity of the hindfoot, but no midfoot abduction, while in Stage II b midfoot abduction is present. In stage III, patients will have fixed deformity with hindfoot valgus and forefoot abduction. Patients with stage IV deformity will have ankle valgus secondary to deltoid ligament attenuation (7, 8). The flatfoot can also be acquired from pre hallux bone; it is the supernumerary bone in the human foot, which appears as a rudiment of the toe on the preaxial side of the hallux. It is attached or fused with the inner border of the scaphoid it usually lies directly internal to the scaphoid. The attachment of the posterior tibialis tendon usually attaches the navicular and medial cuneiform bone, due to the presence of pre hallux the insertion of the posterior tibialis tendon is to the undersurface of the scaphoid tubercle. This attachment may influence on flatfoot. Infants and young children are prone to absence arches. Infants have a fat pad under the medial longitudinal arch which server to protect the arch during early childhood. Normally arches developed by the age of 5 or 6 years and it always remains to be flexible if the children are encountered with flatfoot. Some of the children will fail to develop a normal arch by adulthood. Obesity will be the main cause of children who fail to develop a normal arch. Genetic components may also result in the congenital flatfoot. The abnormal insertion of the tibialis posterior tendon with an accessory navicular bone may also lead to Adult acquired flatfoot deformity (9-11).

The prevalence of flatfoot among children between 3 and 6 years is 44%. The children of 3 years affected were about 54% and the children of 6 years affected were about 24%. Whereas in children aged between 8 and 9 the first stage was found in 20% - 21%, the second stage in 7% - 10% of the children and only 3.85% of the children are suffered from the 3rd stage. Only 17% of the children are affected with moderate flexible flatfoot. As the age increases the prevalence of flatfoot decreases, the adult age from 18 – 21 has the prevalence of the flatfoot is 13.6%. The prevalence of flatfoot among the random population tends to be 26.62%. This random population had a greater BMI and greater foot size (12-15).

Due to the lowering of the arch, there is a pronated position of the talocalcaneonavicular or subtalar and the transverse tarsal joint creates medial rotatory stress. Due to the medial rotatory stress, there is an excessive medial rotation of the leg, excessive angulation of the patellar tendon, and excessive pressure on the lateral patellar facet. Lowering of the arch may result in functional leg length inequality tenses the patellar ligaments and the patellar aponeurosis. With pronation of the hindfoot, the forefoot must be adjusted by supinating at the tarsometatarsal joint, it results in dorsiflexion of the first ray it presents from providing its normal weight-bearing support and creates valgus stress at the first metatarsophalangeal. The flat foot is estimated through the location of the navicular should be intersected by the first line. In a severe degree of flat foot, the depression will lie below the first line and even rest on the floor (16). The deformities of the foot can lead to pain, instability, uneven plantar pressure distribution, and gait problems. Therefore, it may affect the vocational, avocational, and activities of daily living for the adults. As the arch is flattened, it predisposed to undue stress and faulty Biomechanics, which leads to pain and difficulty. Therefore, it is necessary to promote foot health for the adults who are encountered with flatfoot (17).

This study aims to normalize the arch of the foot by using a jumping rope. The muscles that work under jumping rope are calf muscles, quadriceps, hamstrings, and gluteus. The calf muscle helps to hoist the arch of the foot. Skipping is suitable for and benefits for all age groups. Skipping had the greater cadence, peak horizontal ground reaction force, peak hip and ankle extensor torques, peak ankle negative power and work, and peak ankle positive power, whereas in second skipping there are no hip extensor torques. The first skipping utilizes the eccentric muscle action, while the second skipping utilize the concentric muscle action. Their various physical benefits of jumping rope, which helps to prevent the risk of the cardiovascular disorder by making the heart muscles stronger. Jumping helps to increase the calcaneum required for healthy bone development, it reduces several bone problems. It also improves hand and eye coordination. The mental benefit of jumping rope includes the proper function of the brain by increasing the blood flow towards the brain. In children, it increases the memory and concentration.

There are various psychological benefits of jumping rope in children as well as in adults. Competitive and motivational skills are improved by jumping rope. Like this, there are various benefits of jumping rope, so the jumping rope is used in this study to normalize the arch (18).

METHODOLOGY

Fifty subjects with bilateral flatfoot were recruited for the study. They acknowledged their participation by signing their informed consent 18 to 20 years of age of the group was included in this study. Subjects who had bilateral flat foot found out using the navicular drop test were selected for this study. Subjects having a clinical disorder such as foot trauma, fracture of talus, rheumatoid arthritis, rupture of the posterior tendon, congenital deformities of foot and ankle, and other neurological disorders were excluded from the study. With a random sampling technique, they were allotted alternatively to group A and group B respectively. Group A includes 20 subjects with bilateral flat foot receiving jumping rope with barefoot and group B, 20 subjects with bilateral flat foot receiving conventional exercises of the foot. The pre and post-measurement were evaluated for all the subjects by the main investigating physiotherapist. The subjects were evaluated by the navicular drop test. The test was performed to all the subjects in weight bearing and non-weight bearing position.

The materials used for this study were custom-made index cards, inch tape, marker, jumping rope, and pencil. First, palpated the subject's navicular tuberosity and marked with a marker. Subjects are made to sit with hip and knee flexed to 90 degrees. By using a custom-made index card, the navicular tuberosity point is marked in a weight-bearing position later in a non-weight bearing position. The instruction given to the subjects was to transmit weight in both legs and the ankle and subtalar joint should be maintained in a neutral position. The difference between weight bearing and non-weight bearing should be less than 10 mm. According to Brody's navicular drop test if values are 10 mm or more than 10 mm consider being flat foot, less than 10 mm considered to be normal.

The subjects of group A were assigned to perform jumping rope; the jump was performed in barefoot and asked to do jumps in toes. Session – 3 sessions/day, Repetitions – 10 repetitions/day, Rest time – 5 seconds, Hold time – 10 seconds, Frequency – 5 days/week, Duration – 8 weeks.

Group B was assigned to do conservative management of foot. The conventional exercises of the foot such as barefoot exercises consisted of active movement given in the order.

Short foot exercises: The subjects are instructed to pull the first metatarsal head towards the heel without toe flexion.

Gastrocnemius stretch: The subjects are instructed to stand about three feet from a wall and put their right foot behind them ensuring their toes are facing forward. Keep your heel on the ground and lean forward with your right knee straight.

Soleus stretch: The subjects are instructed to stand away from a wall and put their foot behind and ensuring their toes are facing forward. Lean forward at the ankle while bending the right knee and keeping their heel on the ground.

Toe lifting: The subjects are instructed to raise the toes and forefoot off the floor to strengthen the shin muscles keeping their heels on the ground.

Heel lifting: The subjects are instructed to raise the heel keeping their toes and forefoot on the ground.

Exercise protocol for barefoot exercise

Session – 2 sessions/day, Repetitions – 5 repetitions/day, Rest time – 3 seconds, Hold time – 6 seconds, Frequency – 5 days/week, Duration – 3 weeks.

The main investigating physiotherapist conducted the pre and post measures. The data collected was taken for statistical analysis to compare the effectiveness of exercises between these two groups.

Statistical analysis

Statistical analysis was done on a blinded, intention to treat basis using SPSS software (version 18.0). Paired t test were conducted to compare the states between before and after intervention in each group. Unpaired t test were conducted for the intergroup comparison to determine the differences between the two groups. $P<0.05$ was set for all analyses and the significance level was set to $\alpha = 0.05$.

RESULTS

From the statistical analysis made with the quantitative data revealed statistically significant differences within group A and group B. The post-test mean value of the navicular drop test for group A and group B (RIGHT) are 16.396 and 15.153 with a standard deviation of (RIGHT) 40.154 and 37.578 respectively. The post-test mean value of the navicular drop test for group A and group B (LEFT) are 14.809 and 21.839 with a standard deviation of (LEFT) are 36.231 and 53.837. This shows that group A is greater in improving the medial longitudinal arch than group B. Group A shows in functional performance than group B. Statistical analysis of post-test revealed that there is a statistically significant difference seen between group A and group B.

Table 1: Comparison between the values of group A pre-test and post-test values (Right)

Group Name	n	Mean	SD
Group A Pre-Right	29	2.853	51.054
Group A Post Right	29	16.396	40.154

Table 2: Comparison between the values of group A pre-test and post-test values (Left)

Group Name	n	Mean	SD
Group A Pre-Left	29	18.075	41.402
Group A Post Left	29	14.809	36.231

Table 3: Comparison between the values of group B pre-test and post-test values (Right)

Group Name	n	Mean	SD
Group B Pre-Right	29	20.593	50.879
Group B Post Right	29	15.153	37.578

Table 4: Comparison between the values of group B pre-test and post-test values (Left)

Group Name	n	Mean	SD
Group B Pre-Left	29	21.839	53.837
Group B Post Left	29	16.550	40.897

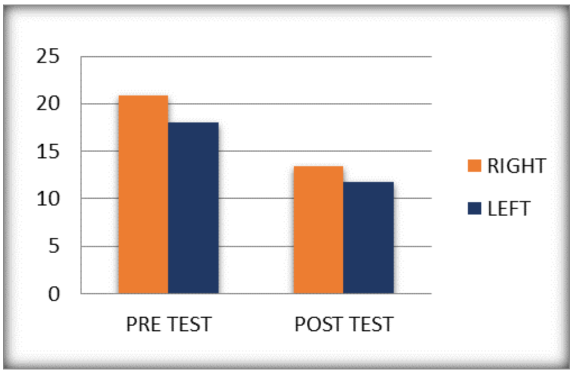

Fig. 1: Navicular Drop Test- Group A

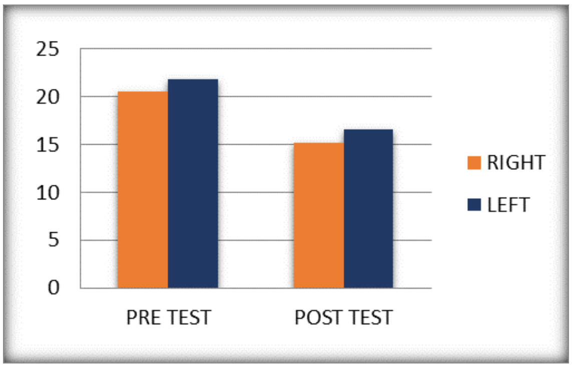

Fig. 2: Navicular Drop Test- Group B

DISCUSSION

The purpose of the study was to normalize the arch of the subjects with the bilateral flat foot with jumping rope and with some conventional exercises of the foot that helps to normalize the arch. This comparison is demonstrated with duration of eight weeks session which is performed by three sessions per day. The outcome result was measured with the navicular drop test, as the test is considered to be reliable and valid. Before doing this test, the foot should be checked for rigid or flexible flatfoot by the tiptoe test , which is used to see if subject have flexible or rigid flat feet. If a visible-arch forms when you stand on your toes, you have flexible flat feet. If not, would likely recommend treatment for a rigid flat foot. The groups were synchronized with age, sex, and pre-measurements of the navicular drop test (19, 20). Beneficial effects were significantly greater in jumping rope than that of conventional exercises of the foot. With proper position and method, we can reduce the strain in Achilles tendon. There are various techniques used in normalizing the arch of the flatfoot such as various physical exercises of the foot which included toe curls, toe yoga, and some stretching and strengthening exercises of the leg such as calf stretch arch muscle strengthening and heel rises. The pain caused by flatfoot can be managed by the modalities such as heat therapy, cold therapy, ultrasound, pulsed electrical stimulation. The physical appliances used in managing the flatfoot are orthotics or the passive arch supports, proper footwear, insoles that used to lift the arches of the foot, and the jumping rope (21, 22). In this study jumping rope with barefoot and conventional exercises to footwear used in treating bilateral flatfoot. In case of congenital conditions like those that cerebral palsy flatfoot can be corrected with the use of orthotic/ bracing/ insole/ splint to achieve some independence in functional activity.

There are various studies regarding the treatment of flatfoot. Koutsogiannis, in the study of treatment of mobile flatfoot, by displacement osteotomy of the calcaneus, discussed the displacement of the posterior part of calcaneus medially and to restore the weight-bearing function of the foot. Rao and Joseph in the study of the influence of footwear on the prevalence of flatfoot had suggested that wearing proper footwear might help in normalizing the arch. Augustin *et al.*, in the study of non-operative treatment of adult acquires flatfoot with Arizona brace, suggested the usage of Arizona AFO brace in treating the acquired flatfoot (23-25).

In this study, jumping rope with barefoot and conventional exercises of the foot was used in treating flat foot. Group A had performed jumping rope barefoot in three sets per day and group B had performed conventional exercises of foot each of three sessions with ten repetitions every day. Pre and post-measurement were taken. The result of this study shows that there was a normalization of an arch in both groups. In group B it may be due to that it helps in the reduction of pain caused by the flat foot and there is a slight increase in the arch by those conventional exercises of the foot. The benefits of conventional exercises of the foot help to reduce the complications and injuries of a flat foot, thus it reduces the symptoms of flat foot and helps in decreasing the complications of the leg such as leg length discriminant, etc.

The result of the study may be applied to the general population with a bilateral flat foot. The study did not include a follow-up period and therefore no conclusion can be drawn about the long-term benefits of the interventions.

The greater effects of jumping rope maybe because it helps to strengthen the calf muscle, which is the main muscle to hoist the arch. Therefore, the jumping rope protects the foot from further injury of the flat foot. The most caused effective management of the flat foot is the jumping rope. However, the conventional exercises of the foot may also help to normalize the arch, which cannot be performed efficiently by all the individuals, which takes more time to normalize the arch. The jumping rope helps to strengthen the calf muscle which is the key muscle to maintain the arch. Finally, this experimental study provides a piece of evidence to support the use of jumping rope in the short-term management of the flat foot. Further studies could focus on long term benefits of physical therapy for this condition and relative effectiveness of this treatment regimens compared with other approaches. The long-term effects of jumping rope and conventional exercises of the foot with barefoot can be evaluated for the bilateral flat foot with a large -scale group.

CONCLUSION

The study concluded that both the groups resulted in a positive outcome, but the group who had to skip barefoot had shown a higher level of a positive outcome in terms of decreasing the pain and normalizing the arch of the foot when compared to another group who had performed conventional exercises of the foot.

CONFLICT OF INTEREST

There is no conflict of interest from other authors.

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