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Research article

Effect of lower limb proximal to distal muscle imbalance correction on functional pes planus deformity in young adults

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ABSTRACT

The pes planus deformity is seen more in adults. Pes planus or low foot medial longitudinal arch, contributes to lower extremity injury due to the muscular imbalance. This deformity causes proximal to distal muscle imbalance in lower limb. Effective correction of muscle imbalance is prime important in correction of pes planus. The purpose of the study was to find the effect of exercise in pes planus to correct the imbalance, improve the condition & prevent the injuries along with the long-term effect of the pes planus deformity. To study and find the effect of lower limb proximal to distal muscle imbalance correction in pes planus deformity in young adults. 40 people with functional pes planus deformity were randomly assigned to a group that received the baseline treatment for the muscle imbalance along with the intrinsic muscle strengthening exercises (experimental group) or a group that received only intrinsic muscle strengthening exercises (control group). Each group received 6 weeks treatment. Statistical analysis were performed using paired t test and unpaired t test. In pre-intervention, there was no statistically significant difference seen with p values for the navicular drop test for the right leg and left leg 0.1127, 0.1504 respectively. Ink test p values for the right leg, left leg 0.4184, 0.8719 respectively. While on comparing the post-interventional values using the unpaired t test, revealed that there was extremely significant difference seen with p value for both legs the navicular drop test was 0.0001 and for the ink test (right leg=0.0008, left leg=0.0318). Our study reported that muscular imbalance corrective exercises along with the intrinsic muscle strengthening was more effective in improving the condition and muscle imbalance caused by the pes planus. So, muscular imbalance corrective exercises and intrinsic muscle strengthening exercises should be recommended to correct the deformity or prevent the abnormalities in people with functional pes planus.

Keywords: Ink test, Muscle Imbalance, Navicular Drop Test, Pes Planus Deformity, Plantar Arch Index

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INTRODUCTION

Pes planus, the commonest deformity seen in young adults. The prevalence rate is more in young adult age group (18-25) which is 11.95%.[1] Pes planus deformity is also known as flat foot. It is the condition in which medial longitudinal arch (MLA) partially or collapses (loss). MLA becomes chronically or abnormally low.1 Pes planus is divided into 2 types flexible/functional and rigid/spastic. Functional pes planus is defining as hypermobile foot with excessive hind foot valgus & less MLA height when weight bearing and the range of motion is normal.[2]

In functional pes planus, the arch is reduced during normal weight bearing & reappears when non-weight bears and toe standing. The main factors that contribute to functional pes planus are excessive tension in the triceps surae, obesity, and posterior tibial Tendon ligaments.[3] It may also result from tight Achilles tendon and calf muscle. Rigid /spastic pes planus has limited mid tarsal motion. The foot continues to flattened arch when non-weight bearing.

The arch serves as an adaptive and flexible base for the entire body.[4] it function to disperse the weight -bearing & acts to store mechanical energy within stretched elastic ligaments during the gait cycle. If the foot becomes deformed, it adapts the function under the condition. So, the dysfunction of medial longitudinal arch complex, specifically relating to the functional pes planus which is usually asymptomatic but can alter the biomechanics of the lower limbs and lumbar spine. It can lead to lower limb pain, fatigue, overuse injuries and postural imbalance. Foot arches are the shock distributor of the body on foot are related to each other & has its effect on the posture and stability.[5-7]

Foot complex plays major role in the gait, posture, balance and any imbalance in this component may alter the function. The center of gravity (COG) passes through the spine due to over pronation of the foot, COG affects the adjacent joints & related muscle.8 intrinsic foot muscle plays major role in providing the foot stability. In pes planus, the intrinsic foot muscles are weak so it will lower the arches & causes over pronation of the foot which unable to support the limb. So, they need be strengthened.

The head of the talus displace medially & distally from navicular bone. It leads to individuals with pes planus loses the function due to which the calcanonavicular ligaments of the foot stretches severely. The deformity increases the risk of the tendinitis which affect the Achilles tendon due to increase stress over the heel and ankle. Gluteal muscle counteracts the gravity of hip abduction. They provide the leg alignment & eccentrically controlling the abduction and internal rotation of thigh. Gluteus Medius/ Maximus, hip external rotator tends to be weakened in various lower limb body muscle imbalance so it will be better to be strengthen the glutes.

Adductors, hip flexor complex, biceps femoris short head are the inner thigh muscle, hip flexors and outer hamstring. Over pronation causes the bow knee inward & increase the valgus angle of knee. Pes planus impose extra pressure on the muscle & joints and causes shin splint, a condition which lead to pain along the inner edge of the tibia. The people with pes planus are more prone to develop tibial stress fracture. In upper limb on study on proximal to distal approach by Goti TS and Shinde SB shown effective for shoulder immobilization9. There are studies which showing that effect of intrinsic & gluteal muscle strengthening on the flat foot, posterior tibial dysfunction treatment in pes planus, hip joint instability in functional flat foot. However, there was no study that shows the effect of proximal to distal muscular imbalance correction on lower limb. Our study will bridge the gap created by less clarity in lower extremity kinetic chain muscular imbalance in pes planus deformity.

The motive of this study was to improve the alter biomechanics was disturbed; regain the balance & strength of the muscle will lead to work coordinatively. To improve the muscle balance between agonist and antagonist, strengthen the weak and stretch the tight muscle. Physiotherapy treatment is helpful in treating such deformities & imbalance.

The protocol has been set to address all proximal to distal muscle imbalances in lower limb, abductors will be strengthened and adductors muscle stretch will be given vice a versa to balance the lower limb. So, it will be necessary to correct the imbalance between the muscle to improve the condition & cure the deformity.

MATERIALS AND METHODS

It was an experimental study conducted in the Physiotherapy Department of Krishna Institute of Medical Sciences "Deemed To Be University" Karad.

Subject criteria

Total 40 subjects were assessed in two groups (control group=20, experimental group=20) mean age 21 years (range between18 – 25 years). Subjects were included in study 1) Age group 18 -25 years 2) Subject willing to participate 3) Navicular drop >10mm 4) Plantar arch index>1.15 5) Both genders. The subjects were excluded from the study 1) Arthritis 2) Foot or ankle surgery 3) Diabetes 4) Any foot abnormality

Procedure

An approval for the study was been obtained from the Protocol committee and the Institutional Ethical committee of the KIMSDU.

After the concern, the subject had been approached for the purpose of study.

The procedure had been explained & written informed consent taken from those willing to participating. Demographic information of the subjects was taken.

The study was done in 6 months duration and was conducted in Karad.

Total 40 subjects were equally divided into 2 groups using random sampling.

Baseline treatment was given to both the groups.

Group A was given proximal to distal muscle imbalance correction along with the intrinsic muscle strengthening and the Group B was given intrinsic muscle strengthening.

Subjects were selected based on the inclusion and exclusion criteria. Informed consent was taken from the subjects & were assessed for ink test, Navicular drop test.

The result of the study was done based on the detailed assessment.

Exercise Protocol- (42 Days)

A] FOOT EXERCISES (10 times 3 sets and Progression to 5sets after

3 weeks and continued up to 6 weeks)

- Short foot exercises
- Ball roll exercises
- Toe exercises
- Towel curls
- Arch lift

B] GLUTEAL STRENGTHNING EXERCISES (15 times 2 sets and Progression to 3 sets after 3 weeks and continued up to 6 weeks)

- Clamshell
- Hip abduction
- Squat
- 4-point kneeling hip extension (5times)

C] ADDUCTOR STRECHES (5 times, progression to 7 times after 3 weeks and continued up to 6 weeks)

- Butterfly stretches
- Adductor lunge stretch
- Calf muscle stretch

Outcome measures

For the assessment of pes planus deformity, we used ink test. Footprints of all 40 subjects were obtained using simple ink print method. Then a large piece of sponge placed on a tray and diluted ink is poured and wetted. The sponge absorbed all the ink and when the foot was placed it stick to the foot. Then the foot is placed on the white piece of paper for the footprint. Plantar arch index was (PAI) was calculated by drawing the tangential line connecting the edge of the medial forefoot & heel region. From this point the perpendicular line is drawn crossing the footprint. Formula: Plantar arch index (PAI) = A/B.

The 2nd outcome measure we used is navicular drop test for all the subjects. The subjects asked to be in full weight bearing standing position & ensure the foot is in neutral position. Mark the most prominent part of the navicular tuberosity and measure the distance from the supporting surface. Ask the patient to relax and then measure excursion of navicular drop.

STATISTICAL ANALYSIS

The outcome measures were assessed. The collected data in this study was statistically analyzed using statistics mean, SD. The outcome measures are ink test and navicular drop test. The experimental & control group pre and post values were analyzed using paired t test and intergroup by using unpaired t test.

RESULTS AND DISCUSSION

Table no. 1 shows that navicular drop test- intragroup comparison using paired t test. The pre-interventional mean score for Group A (Experimental) right 12.7±2.812, left 12.6±2.186 & post interventional score right 9.775±1.281, left 9.505±0. 9589. In Group B (Control) pre-interventional mean of navicular drop score for the right 14.1±2.634, left 13.8±2.913 & post intervention score for the right 11.995±1.854, left 11.87±2.280. Group A intra group analysis of navicular drop test was revealed significantly reduction in navicular drop post-interventional for both groups. This was done using paired t test Group A Group B (p<0.0001)

Table no. 2 shows that ink test- intragroup comparison using paired t test. The pre-interventional of the ink test score for Group A right 1.257±0.075, left 1.245±0.0719 & post interventional score for the right 1.445±0.019, left 1.147±0.02050. In the group B pre- interventional score for the ink test right 1.2786±0.086, left leg 1.2585±0.0133. Group A intra analysis of ink test revealed a significantly reduction in ink test post interventional groups. The study was done using paired t test Group A and Group B (p<0.0001)

Table no. 3 shows that comparison of pre and post navicular drops test score between the groups. The pre-interventional mean score for the right 12.7±2.812, left 12.6±2.186 of the Group A & for the Group B right 14.1±2.186, left 13.8±2.931. Statistical study shows that there was no significant difference between the pre-intervention inter-group analysis p<0.1127, p<0.1504 respectively. However, in the post intervention score was statistically significant between the 2 groups p<0.0001. Post intervention score was reduced more in the Group A than Group B.

Table no. 4 shows that the comparison of pre and post ink test score between the groups. The pre-interventional mean score for the right 1.2575±0.00758, left 1.2545±0.07149 of Group A & Group B right 1.2785±0.0862, left 1.2585±0.08327. Statistical study shows that there was no significant difference between pre -intervention inter-group analysis p<0.4184, p<0.8719. However, in the post intervention score was statistically significant between 2 groups p<0.0008, p<0.0318. Post intervention score was reduced more in Group A than Group B.

Table 1: Comparison of pre and post-navicular drop score within the group

Navicular drop test		Pre-Mean (Mean±SD)	Post Mean (Mean±SD)	Mean Difference	Paired 't' test	P value
Experimental group (A)	Right leg	12.7±2.812	9.775±1.281	2.925	t=5.885	p<0.0001
	Left leg	12.6±2.186	9.505±0.9589	3.095	t=7.274	p<0.0001
Control group(B)	Right leg	14.1±2.634	11.995±1.854	2.105	t=7.798	p<0.0001
	Left leg	13.8±2.931	11.87±2.280	1.930	t=7.350	p<0.0001

**<0.0001, extremely significant, SD: standard deviation

Table 2: Comparison of pre and post Ink test score within the group.

Ink test		Pre-Mean (Mean±SD)	Post Mean (Mean±SD)	Mean Difference	Paired 't' test	p value
Experimental group (A)	Right leg	1.257±0.075	1.1445±0.019	0.1130	t=7.232	p<0.0001
	Left	1.245±0.07	1.147±0.020	0.1075	t=7.16	p<0.00

	leg	19	50		4	01
Control group (B)	**Right leg**	1.2786±0.086	1.206±0.0743	0.0725	t=7.431	p<0.0001
	Left leg	1.2585±0.083	1.1785±0.0133	0.0800	t=8.585	p<0.0001

**<0.0001, extremely significant, SD: standard deviation

Table 3: Comparison of pre and post Navicular drop test score between groups.

Navicular Drop Test	**Experimental Group (A) (Mean±SD)**	**Control Group (B) (Mean±SD)**	**Mean Difference**	**Unpaired 't' test**	**p value**
PRE-TEST					
Right leg	12.7±2.812	14.1±2.634	1.400	t=1.625	p<0.1127
Left leg	12.6±2.186	13.8±2.931	1.200	t=1.468	p<0.1504
POST TEST					
Right leg	9.775±1.281	11.995±1.854	2.220	t=4.406	p<0.0001
Left leg	9.505±0.9589	11.87±2.280	2.365	t=4.276	p<0.0001

**<0.0001, extremely significant, SD: standard deviation

Table 4: Comparison of pre and post Ink test score between the groups.

Ink test	**Experimental Group (A) (Mean±SD)**	**Control Group (B) (Mean±SD)**	**Mean Difference**	**Unpaired 't' test**	**p value**
PRE-TEST					
Right leg	1.2575±0.0758	1.2785±0.0862	0.02100	t=0.8180	p<0.4184
Left leg	1.2545±0.07149	1.2585±0.08327	0.0040	t=0.1623	p<0.8719
POST TEST					
Right leg	1.1445±0.01932	1.0265±0.07400	0.0620	t=3.625	p<0.0008
Left leg	1.147±0.0205	1.1785±0.0597	0.03150	t=2.229	p<0.0318

**<0.0001, extremely significant, SD: standard deviation

DISCUSSION

The purpose of the study to find out effect of the proximal to distal muscle imbalance correction on functional pes planus deformity. The pes planus causes the muscle imbalance in lower limb, due to the center of gravity the biomechanical chain gets affected easily. Dysfunction of the arch can cause the gait deformity, postural imbalance and other muscular imbalance. The study conducted by Bhoir et. al. stated that the prevalence of the functional pes planus in young adults is 11.25%.[1]

The baseline treatment intrinsic muscle strengthening was given to the subjects of Group A., This improve the condition which was proved by Headlee DL at. El.[10] However, the it was common in both groups so, the benefits cannot be completely imputed to the intrinsic muscle strengthening.

The protocol was set to improve muscle imbalance caused by pes planus included proximal to distal muscle exercises, intrinsic & gluteal muscle strengthening, adductor & calf muscle stretches, were given to Group B. Then outcome was measured with the help of special test.

However, in our study we found that intrinsic along with gluteal muscle strengthening, adductor & calf muscle stretch were more effective than control groups. But the exercises were given to the Group A was more satisfactory than the Group B.

In previous studies, Jung DY et.al. Stated that weakness & dysfunction of the hip external rotator can lead to hip adduction & medial rotation and dynamic knee valgus, which can affect the foot pronation.[11-13] So, hip instability can affect the foot and instability of foot can also affect the foot pronation vice a versa.

In pes planus deformity, intrinsic muscle, adductor muscle, calf muscle, gluteal muscle, hip flexor /extensor muscles are specifically involved due to alter in biomechanics. According to our study, gluteal muscle strengthening, squatting, 4-point kneeling, clamshell, hip abduction exercises were effective to strengthen the muscle & improve the instability. For the adductors and increase knee valgus, butterfly stretch and adductor lunge stretch were more effective.

Calf muscles are probably tight will not allow full and proper movement of ankle and foot joints resulting collapse of the mid foot in early pronation. The calf muscle stretches were useful to improve the fallen arches and loosen muscle.

The previous studies done by Graham et.al. and Jagdish bhai SR, Shinde SB proved that stabilization of the distal segment in closed chain exercise squatting reduces the moving proximal joint shear forces in providing stability in proximal joint movement.[14] Postural imbalance, gait deformities, lumbar instability, knock knee, hip instability are the long-term complication of the functional pes planus deformity. The muscle imbalance corrective exercise was beneficial for the people with pes planus. To prevent injuries to arches of feet the conditioning program is useful to amateur female marathon runners effective in reducing their risk of injuries and problems related to women's health that occur while running a marathon[15]. Foot injury Preventive strategies also integrated by Khutale M, Shinde SB in their advanced strengthening for injury prone pre- military trainee cadets.16 also with integration of motor strategies for fall prevention in elderly by Phatak IV, Chavan SR, and Shinde SB.[17]

Our study also has few limitations. The sample size of the study was less, protocol was of short duration. It is recommended that, further studies should include diverse population, long term surveillance, and advanced diagnostic equipment's for more effective study.

Studies reported that several algae are able to produce EPA and DHA, even in large quantities. It was known that each group of organisms have their distinctive fatty acid profile with individual specific biologically important fatty acids which can be act as

biomarkers for that typical class of organisms. [24] It was also found that several filamentous fungi may also secrete large quantities of EPA and DHA. [25]

CONCLUSION

On the basis of the results, it was concluded that, there was extreme significant effect of the exercises were given to correct the muscle imbalance.

CLINICAL SIGNIFICANCE

The lower limb muscle imbalance correction was very effective. With the help of this knowledge we can treat the patients with pes planus deformity and muscle imbalance.

CONFLICTS OF INTEREST

There were no conflicts of interest in this study.

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AUTHORS CONTRIBUTION

Sawant Janhavi conducted the discussion of the study, findings, collected data and analyzed the data, literature review, developed introduction section for this manuscript. Sandeep Shinde provided a description of the background information, collected data and analyze the data and participated in preparation of the manuscript.

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ABBREVIATIONS

COG- Center of Gravity

MLA- Medial Longitudinal Arch

PAI- Plantar Arch Index

ROM-Range of Motion

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