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EFFECTS OF INTRINSIC FOOT MUSCLES TRAINING ON MEDIAL LONGITUDINAL ARCH IN PATIENTS WITH DIABETIC NEUROPATHY

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ABSTRACT

BACKGROUND: Foot deformities continue to be a risk factor for the loss of medial longitudinal arch in patients with diabetic neuropathy. Different interventions have been performed to find the most effective methods to improve the height of the medial longitudinal arch. **OBJECTIVE:** The purpose of the study therefore, is to explore the effects on the height of the arch in patients with diabetic neuropathy by exercises intervention. **STUDY DESIGN:** Experimental study design, pre and post study type. **PROCEDURE:** Based on the inclusion and exclusion criteria, 30 subjects were divided into 2 groups by lot system, group A(experimental group) and group B(control group). Group A received exercises intervention for over a period of 4 weeks and group B received conventional physiotherapy like home based exercises and footwear modifications (common in both groups) for over a period of 4 weeks. **RESULTS:** At the end of the study, there was a significant difference in group A with p value .000($p<0.05$) in vernier caliper measurement and p value .024($p<0.05$) in feiss line test. Group B showed no significant difference with p value .231($p>0.05$) in vernier caliper measurement and p value .444($p>0.05$) in feiss line test**. CONCLUSION:** This study concludes that the training of intrinsic foot muscles increases the height of medial longitudinal arch by exercises intervention.

KEYWORDS: Medial longitudinal arch, Diabetic neuropathy, Intrinsic foot muscles, Vernier caliper, Feiss line test, Exercises.

INTRODUCTION

Diabetes, a disease in which the blood glucose level in the body is high, either because of inadequate insulin production or inability of the body's cell to respond to insulin. It is a disease of endemic proportion all over the world, affecting around 150 million people. Diabetes in overtime can lead to diabetic neuropathy, which is a common complication in both type 1 and type 2 diabetes[1].

Diabetic neuropathy is a nerve disorder caused by diabetes, because of the damage of blood vessels that provides the nerve with oxygen and nutrition. In chronic case of diabetes, nerve damage develops throughout the body. People affected by diabetic neuropathy may not have any symptoms or may be characterized by pain, sensory loss, or tingling sensation in arms, hands, legs and feet widely.

Feet becomes the target of almost all the chronic complications to a which diabetic patient is subjected. Medial longitudinal arch collapse is one of the complications, diabetic patients suffer. Medial Longitudinal Arch is commonly referred to as simply "the arch" in foot. This arch acts as a spring and is responsible in absorbing the maximum shock of impact while walking, running and jumping. Intrinsic foot muscles like flexor digitorium brevis, flexor digitorium longus, flexor hallucis longus, tibialis anterior and tibialis posterior provide the muscular support to medial longitudinal arch. Motor neuropathy produces disarrangements of all these muscles, causing its atrophy and resultant loss of joint mobility, particularly the subtalar and metatarsal phalangeal muscles.[5]

Since intrinsic muscles of the foot, comprising of 1st, 2nd and 3rd layers of foot are responsible for maintaining the medial arch. So strengthening of intrinsic foot muscles are used as the therapeutic intervention for stabilizing the arch as well as increasing the height of the medial longitudinal arch. In diabetic neuropathy too motor deficit are evident, so strengthening of intrinsic muscles can be applied in these particular area.

Research confirms strengthening of intrinsic foot muscle helps in restoration of medial longitudinal arch, but research regarding the strengthening of intrinsic foot muscle on medial longitudinal arch in pathological condition such as diabetes is sparse.[9]

Therefore this study focuses on the effectiveness of intrinsic foot muscle strengthening on medial longitudinal arch in patients with Diabetic Neuropathy.The aim of the study is to find the effectiveness of intrinsic foot muscles strengthening on medial longitudinal arch in patients with diabetic neuropathy.The deterioration of intrinsic foot muscles may play an important role in foot deformity, according to recent research. Therefore this study emphasizes in the ways in which foot exercise may strengthen the intrinsic foot muscles in patients with loss of arch caused due to diabetic neuropathy, and moreover to implement the physical training to feet which is usually ignored.

METHODOLOGY

This study is an Experimental study with Pre-and Post Type. 30 subjects were selected by Random Sampling method.Study conducted at SRM Hospital and Research Centre, Kattankulathur for 4 weeks. Both Men and Women of 40-60 years of age selected for study subjects with Adult Acquired flatfoot deformity (AAFD) and subjects with Unilateral flat foot and with Navicular drop height >7mm selected Both Type1 and Type2 diabetic patients with Wet test positive were included in the study. Patients with Charcot Arthropathy or patients Inherited flatfoot or Patients with large plantar ulcers were excluded from the study.

PROCEDURE

30 subjects were included in the study based on the inclusion and exclusion criteria. The procedure was explained to the subjects and informed consent were obtained from them. The subjects were included only after the wet test, the wet test was performed for all the subjects to find the presence of pes planus. The subjects were asked to immersed their foot completely in the water and then step on a white paper so that the evaluation of flatfoot could be done visually seeing the foot print.

Subjects were divided into two groups, group A (experimental group) and group B (control group) by lot system. Subjects were presented with two paper sheets written number 1 and 2 on each paper folded to blind from subjects. Subjects picking no 1 marked paper were allotted to experimental group and the subjects picking no 2 marked paper were allotted to control group.

GROUP A - INTERVENTION

Before the intervention, subjects were taught about the warm up. The subjects were asked to do active stretch the foot muscle in standing position. This warm up was done for about 2 minutes.

Toe Lifts -The subjects were made to stand and asked to lift the toes actively for 3 sets of 15 repetitions each, with an interval of 1 minute after every set.

Toe Curls - Subjects were made to stand with affected leg forward with a hand towel placed under the foot. Now subjects were asked to grasp the towel as tight as possible. This exercise was repeated for 5 times.

Big Toe Stretch-The subjects were made to sit on a chair and were taught to perform the self-stretching technique of the big toe by pulling the toe towards the ankle. This stretching was held for 15 seconds and was done for 8 times

Marble Pick Up-The subjects were asked to sit on a chair and pick up marbles that are on the floor using the toes and place it on a bowl or basket kept at a distance from the marbles. The subjects picked up 20 marbles in 1 set in a day.

Rolling Ball-The subjects were made to sit on a chair and place a tennis ball under the feet and asked to roll the ball using their sole. This exercise was repeated 2 times in a day for 2 minutes each.

Rock and Roll-The subjects were asked to stand and place their feet on the ground and gradually raise the heels upward and simultaneously invert the feet and go back to the initial position. This exercise was performed for 12 repetitions for 1 set in a day.

Smart Toes-Subjects were asked to stand with affected foot forward. They were asked to press the foot against the ground trying to elongate their foot than normal. This exercise was done for 12 times/set/day.

Foot Fold- Subjects were asked to maintain the standing position and were asked to place the affected foot forward bearing the maximum weight of the body. Now they were asked to gradually lift their heel as high as possible, putting maximum weight on their ball of the foot. This exercise was performed for 12times/set/day.

All exercises were clearly demonstrated and explained to them. They were provided with a log sheet containing for weekly exercises. The subjects were asked to make an entry after performing the exercises. This log was checked for its genuineness by random visits to subjects home. This log was also checked when subjects came for their consultation with diabetologist, on those occasions supervised exercises were performed in OPD itself.

GROUP B - INTERVENTION

CONVENTIONAL PHYSIOTHERAPY- Home Based Exercises

Calf Stretching : The subjects were taught to perform the self-stretching for the calf muscles. They were asked to stand and place their forefoot of their affected leg against the wall or any objects so that the foot is maintained in an inclined position in which the heel is in contact with the ground and toes off the ground against the wall or on the objects.

Toe Stretching: Subjects were taught to perform self-stretching of their toes by holding the two ends of the towel with their hands and placing the towel on their toes and pulling the ends of towel closer to the chest.

Toe Standing : The subjects were asked to stand and lift their heels off the ground transferring their body weight to the toes. This exercise was performed for 3 sets of 15 repititions.

All the exercises taught to them were clearly explained, demonstrated practically and asked to perform each stretch for 15 seconds for 8 stretches.

Footwear Modifications-

All the subjects of both group A and B were advised to wear MCR footwear with elevation at the center. They were asked to wear the footwear inside the house as well as during their working hours.

OUTCOME MEASURES

NAVICULAR HEIGHT

Navicular height was measured using a digital vernier caliper. The subjects were asked to stand in a neutral position without any weight bearing, and the navicular tuberosity was palpated. A point was marked on the navicular tuberosity with a ball pen. The subjects were again asked to go for weight bearing position and the navicular tuberosity for the same affected foot was palpated and marked using the same ball pen. The difference between the two points were measured using the jaws of vernier caliper. The reading obtained on the digital caliper was recorded. All the values were measured in millimeters.

FEISS LINE TEST

The subjects were asked to stand in a neutral position. Three points were drawn on subjects foot at the medial malleolus, navicular tuberosity and head of the first metatarsal bone. A line was drawn using a 30cm scale from medial malleolus to the head of the first metatarsal bone. The subjects were considered flatfoot if the navicular tuberosity lied below the line. The perpendicular distance from the navicular tuberosity and the line was drawn. The perpendicular distance was measured in centimeters.

The measured data obtained from the subjects using the vernier caliper and feiss line test was assessed and measure on the 1st day of the 1st week and end of the 4th week.

DATA ANALYSIS

The collected data were analyzed and tabulated with descriptive and interferential statistics. For the descriptive statistics, the mean and standard deviation were calculated and for interferential statistics, the parametric variables were calculated with t-test. The results were tabulated and graphs were plotted accordingly. Data analysis was done by using IBM SPSS STATISTICS 20.

GROUP A	MEAN	N	Std Deviation	T Value	P Value
PRETEST	11.2667	15	3.04370	8.703	.000
POSTTEST	4.5920	15	1.93940		

TABLE-1 : Pre-Test And Post-Test Values Of Navicular Drop Height In Group A Subjects By Using Vernier Caliper. P<0.05

GROUP B	MEAN	N	Std Deviation	T Value	P Value
PRETEST	11.5480	15	2.09487	1.252	.231
POSTTEST	10.7133	15	1.83823		

TABLE 2 - Pre And Post Test Values Of Navicular Drop Height In Group B Subjects By Using Vernier Caliper.P>0.05

GROUP A	MEAN	N	Std Deviation	T Value	P Value
PRETEST	1.0600	15	.34806	8.264	.000
POSTTEST	.5533	15	.31137		

TABLE 3 -Pre And Post Test Values Of Navicular Drop Height In Group A Subjects By Using Feiss Line Test P<0.05

GROUP B	MEAN	N	Std Deviation	T Value	P Value
PRETEST	.8067	15	.26313	-.788	.444
POSTTEST	.8533	15	.37391		

TABLE 4 - Pre And Post Test Values Of Navicular Drop Height In Group B Subjects By Using Feiss Line Test.

VERNIER CALIPER TEST	N	MEAN	Std Deviation	T Value	P Value
GROUP A	15	4.5920	1.93940	-8.872	.000
GROUP B	15	10.7133	1.83823		

Table 5 - Comparison Of Pre And Post Test Values Of Navicular Drop Height In Group A And Group B Subjects By Using Vernier Caliper. P<0.05

FEISS LINE TEST	N	MEAN	Std Deviation	T Value	P Value
GROUP A	15	.5533	.31137	-2.388	.024
GROUP B	15	.8533	.37391		

Table 6-Comparison Of Pre And Post Test Values Of Navicular Drop Height In Group A And Group B Subjects By Using Feiss Line Test. P<0.05

DISCUSSION

The aim of the study was to find the effects of intrinsic foot muscles training on medial longitudinal arch in patients with diabetic neuropathy. This study was focused on the subjects with diabetic neuropathy causing the loss of medial arch, due to the weakness of muscles especially in the feet. Since the feet are commonly affected in diabetes, the muscles of the foot responsible for weight bearing, maintaining the posture and arches and other soft tissues may weaken, leading to various types of deformities in foot, among which loss of arch is common in them.

The arch of the foot is maintained and stabilized by the ligaments and intrinsic muscles of the foot. Any weakness or injury to these structures will result in postural deformities to the foot like navicular drop and pronated/everted feet. In this study, attempts were made to improve the height of medial longitudinal arch by training the intrinsic foot muscles in a four weeks program. To make the study more precise, subjects were put into two groups. Group A received intervention for four weeks while the Group B continued with their conventional treatment along with the footwear modification which was common in

both the groups.

According to the result achieved in this study as per the statistical analysis, the mean value of table 1 showed a reduction from 11.2667 to 4.5920 in Group A when measured using vernier caliper. Table 2 also did show differences in Group A from 1.0600 to .5533 when measured using another scale known as feiss line test. The p values for table 1 and 2 were .000. This shows that the arch were improved in the group A. This signifies the possibility of the exercises protocol that might have helped in increasing the height of the arch.

According to table 3 the mean value had a slight reduction from 11.5480 to 10.7133 as per the measurements obtained by the vernier caliper. The feiss line test measurement in table 4 showed negative result, the mean ranging from .8067 to.8533. The p value of both these measurement were .231 and .444 respectively. The faulty foot postures can also result in tightness and laxity of soft tissues within the foot. Orthotics can be used initially to activate the necessary muscles that need to work to maintain the arch or relieve pressure on structures that are bearing loads they should not. However it is not a permanent solution as the root of the problem lies in the weakness of the intrinsic foot muscles. Therefore by increasing the strength and endurance of the intrinsic muscles of the foot, the correct foot posture may regain. Stretching techniques allow tight musculature to return to their correct resting length. In doing so it relieves pain and helps in positioning the foot back into correct posture. The result signifies that there was no improvement of arch. Despite the fact that they were under conventional treatment, they had no signs of improvement. Various possible reasons could be assumed like the insufficiency of the exercises, duration of the treatment or lack of individual's interest.

The analysis concludes with the fact that the height of medial longitudinal arch of Group A had significantly increased when compared to the analysis of Group B. This indicates that the loss of medial longitudinal arch can be revived to normal or close to normal through exercises. Fiolkoski et al, 2008; Campbell et al, 2008; Headlee et al, 2008 T supported that simple interventions of intrinsic muscles have an impact on navicular drop, arch height morphology, and other functions of intrinsic foot. The result of this study are similar to few others that have found that intervention of intrinsic foot muscles activity impact the arch height[6,20]. In another study, Lynn and colleagues concluded that the short foot exercises were effective in strengthening intrinsic foot muscles that was implemented for four weeks[9].

This study is also supported by the study done by Jung et al. which reported that the intrinsic foot muscles were significantly improved when the toe curl exercise was applied[11]. This is attributed to the fact that these exercises can improve the functions and activity of the intrinsic foot muscles that play a vital role in bearing the weight and maintaining the stability of medial longitudinal arch.

In this study, the interventions and exercises for Group A and conventional physiotherapy like foot wear modifications and other home based exercises for Group B were applied to improve the loss of medial longitudinal arch in patients with diabetic neuropathy. It could be seen that the intervention period of four weeks was not enough to improve the medial longitudinal arch in Group B merely by Home Based Exercises and foot wear modifications.

Hence, the study showed that medial longitudinal arch was improved by the measurements of Vernier Caliper and Feiss Line Test as Vernier Caliper is considered the most reliable and accurate measurement for the medial longitudinal arch (Michael B Pohl et al. 2010)[20]. In addition it could be seen that intrinsic foot muscle training for four weeks was by far more effective than conservative treatment methods like foot wear and soles modification.

Regardless of the positivity of this study, the exercises session were non supervised for many subjects, done by the patient itself, merely based on the trust of the entry made by them in the weekly exercise log.Entry of exercise log chart by patients itself is a limitation as there may be erreness entry or bias in the entry.

In future Studies with larger samples can be included and treated under supervision with period of less than 4 weeks. A study with conventional interventions for controlled group can be done with prolonged duration. The arch height can be compared between the caliper and radiographic images. Comparison can be done for the duration required for the treatment in bringing the arch to normal in normal subjects and diabetic group.

CONCLUSION

There is a significant effects of intrinsic foot muscles training on medial longitudinal arch in patients with diabetic neuropathy.

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