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THE EFFICACY OF DYNAMIC STRETCHING EXERCISE VERSUS STRENGTHENING EXERCISE ON LONGITUDINAL MEDIAL ARCH IN FLAT FEET: RANDOMIZED CONTROLLED TRIAL

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Abstract

Introduction – Flat feet need to be treated with the proper exercises. The purpose of this study was to compare the effects of dynamic stretching exercise with strengthening exercise in participants with flat feet. **Methods** – Participants included 73 subjects (12-14 years of age) with variety of flat feet degree who were recruited from a footprint with Arch Index (AI) and then randomly assigned to a dynamic stretching or strengthening treatment group. There were 35 participants in dynamic stretching group and 38 participants in strengthening group. The dynamic stretching treatment consisted of standing hamstring calf stretch, half kneeling with adductor stretch, and iliotibial band stretch. The strengthening treatment consisted of short foot, heel raise, and squat exercise. The main outcome measures were assessed with Independent T test for dependent variables. **Results** – There is statistically a significant difference between pre and post measurement readings with time ($p = 0.00$) and between groups ($p < 0.05$) with respect to longitudinal medial arch after 15 times exercise programs. Analysis showed more favor to dynamic stretching group (mean change, 0.031; 95% confidence interval [CI]: 0.025, 0.036) rather than strengthening group (mean change, 0.021; 95% CI: 0.012, 0.029). **Conclusion** – Our results showed that dynamic stretching exercise programs was more effective in improving fallen longitudinal medial arch than strengthening exercise programs. These findings suggest that dynamic stretching exercise is a valid option for treatment of flat feet.

Key words: dynamic stretching exercise, strengthening exercise, longitudinal medial arch.

INTRODUCTION

The medial longitudinal arch plays an important role in providing the spring force during walking. Problems with the structure and functional of the medial longitudinal arch can cause foot deformities such as flat feet. Flat feet also known as pes planus or fallen arches, is a condition associated with the two arches of the inner legs are not formed, so that all surfaces of the foot contact with the floor (Santoso, 2011). This deformity is caused by weakness of the supporting structure of the medial longitudinal arch, such as the intrinsic muscles of the feet, the plantar ligament, anterior and posterior tibial tendon that can affect postural stability (Sahabuddin, 2016).

The alignment in flat foot will change toward hyperpronation. This faulty alignment may force the muscles in the thighs, legs, and feet to overuse in maintaining postural stability. The continuous force that muscles gain due to prolonged abnormal posture and repetitive motion may change the biomechanics and neurological adaptation. This creates a muscle imbalance (Lardner, et al. 2010). Muscle imbalance will cause the central mass shift to posterior, so that the body alignment from the pelvic to the foot will change. Pelvic will tend to spin forward while the thighs and knees will spin inside. In the long run, the knees and legs of the back will experience valgus and the navicular will drop, resulting in an eversion position in the subtalar joint (Mosca, 2010). Malfunction in the medial longitudinal arches allows the body to fall easily and eventually can damage the body building as a whole.

Based on a survey of a total sample of 50 people with vulnerable ages 14-20 years in South India, the prevalence of 16% of children experienced flat foot (Pranati and Karthik, 2017). The prevalence of flat foot in Europe in children aged 8-13 years was found to be 19.1%

(Evans and Rome, 2011). Meanwhile, based on preliminary study conducted by the author through examination of footprint on students in any junior high school in Makassar, from 440 children studied with vulnerable age 12-14 years found 138 children or 31.36% experienced flat foot and 40 of them experienced flat foot with biomechanical changes in the knee and hind legs (valgus) and decreased navicular resulting in the eversion position of the subtalar joint.

There are many interventions that physiotherapists can do to correct the medial longitudinal arch problem in flat feet, but the most frequently given are strengthening and stretching exercises (Sahabuddin, 2016). Some strengthening exercises are done heel raise, short foot, and squat exercise. These three exercises aim to strengthen the intrinsic muscles of the legs as well as the muscles around the pelvic, thigh, and knee due to the effects of the biomechanical changes that result in muscle imbalance. Furthermore, the dynamic stretching exercises also are an effective method in increase the power, jumping, and walking performance (Perrier et al. 2011).

Further, no work has been done to observe the effects of strengthening and stretching exercise, to date, in improving of longitudinal medial arch in flat feet. This has provided the authors with focus in this work.

METHODS

The data of this study was carried out at junior high school in Makassar. Type of this study is a quasi-experimental with time-series experimental design method. The population was the students with 12-14 years old. The data was collected by performing a medial longitudinal arch examination using a wet footprint test to ensure the respondent was in the flat foot category. The results of the wet footprint test were measured and interpreted according to the Arch Index (AI) category. AI measurements in the footprint are done by making a foot axis first and then drag a horizontal line at the top of the metatarsal and calcaneus. After that, drag a vertical line from the top of the metatarsal to the calcaneus and divide into three parts to determine the specific segments. The parameters on AI, ie $0.21 \leq AI \leq 0.26$ indicated normal and > 0.26 indicated flat foot. Sample size was calculated and determined at 73 participants (35 participants in dynamic stretching group and 38 participants in strengthening group) to find a between-group difference in Arch Index (AI).

Strengthening treatment was prescribed 2 sets of 8 to 12 repetitions for each exercise, with 30 second of rest between each set, until 15 times of treatment, and without provoking pain during exercise. The strengthening treatment consisted of short foot, heel raise, and squat exercise. Each week, higher levels of exercise were given and the participant was allowed to move to the next higher level if he/she was acquainted with the previous level.

Whereas, dynamic stretching treatment was prescribed 3 sets of 8 to 10 repetitions for each exercise, with 30 second of rest between each set, until 15 times of treatment, and without provoking pain during exercise. The dynamic stretching treatment consisted of standing hamstring calf stretch, half kneeling with adductor stretch, and iliotibial band stretch. Each week, higher levels of exercise were given and the participant was allowed to move to the next higher level if he/she was acquainted with the previous level.

The Paired Samples Test was used to observed pre- and post-treatment effect. The error between repeated measures was indicated by the 95% confidence intervals for the absolute differences between trials. The Independent Sample T Test to observe both of post-treatment effect was done using a significance level of 0.05. All the analyses were done by using SPSS 22 statistical software.

RESULTS

Seventy-three respondent with a mean age of 12.78 years completed the study. The mean difference is significant at the 0.05 level. The number male sex sample was 43 persons and female sex sample was 30 persons.

Table 1 lists the baseline and post treatment scores of Arch Index (AI) for all groups investigated in the study. Overall results of the study showed that both groups improved over time, compared to baseline ($p < 0.05$).

As listed in Table 2, there is a significant difference between pre- and post-treatment in all groups ($p < 0.05$). An analysis of paired sample t test was done to discover the effects of treatment between the groups that had shown an improvement in AI values after 15 times, which were statistically significant. Overall results of the study showed that both groups improved over time, compared to baseline ($p < 0.05$). There is statistically a significant difference between pre and post measurement readings with time (p = 0.000) and between groups ($p < 0.05$) with respect to longitudinal medial arch after 15 times exercise programs. Analysis showed more favor to dynamic stretching group for the left foot (mean change, 0.031; 95% confidence interval [CI]: 0.025, 0.036) rather than strengthening group (mean change, 0.021; 95% CI: 0.012, 0.029). For the right foot, the analysis also showed more favor to dynamic stretching group for the left foot (mean change, 0.032; 95% confidence interval [CI]: 0.027, 0.037) rather than strengthening group (mean change, 0.026; 95% CI: 0.015, 0.037).

In Table 3, an analysis of independent sample T test was done to compare the efficacy between the dynamic stretching groups and strengthening groups. There is a significant difference of Arch Index in left foot between post-treatment in dynamic stretching group and post-treatment in strengthening group ($p = 0.022$).

Table 1. Mean (SEM) values of outcome variables

Group	Time	Arch Index (left foot)	Arch Index (right foot)
I (Dynamic Stretching Exercise)	Pre	0.3071(0.00486)	0.3091(0.00437)
	Post	0.2763(0.00422)	0.2769(0.00397)
II (Strengthening Exercise)	Pre	0.3137(0.00375)	0.3111(0.00376)
	Post	0.2930(0.00567)	0.2853(0.00600)

Table 2. Paired Sample T Test to observer the Pre-Post treatment effect

	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2 tailed)
				Lower	Upper			
Pre-Post Arch Index in left foot (Dynamic Stretching)	0.03086	0.01634	0.00276	0.02525	0.03647	11.174	34	0.000*
Pre-Post Arch Index in left foot (Strengthening)	0.02074	0.02723	0.00442	0.01179	0.02969	4.694	37	0.000*
Pre-Post Arch Index in right foot (Dynamic Stretching)	0.03229	0.01437	0.00243	0.02735	0.03722	13.295	34	0.000*
Pre-Post Arch Index in right foot (Strengthening)	0.02579	0.03340	0.00542	0.01481	0.03677	4.759	37	0.000*

***)** significant level

Table 3. Independent Sample T Test to observer the both of Post-treatment effect

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Post Arch Index in left side (Dynamic Stretching versus Strengthening)	5.510	0.022	-2.334	71	0.022*	-0.01671	0.00716	-0.031	-0.002
Post Arch Index in right side (Dynamic Stretching versus Strengthening)	7.537	0.008	-1.155	71	0.252	-0.00846	0.00732	-0.023	0.006

***)** significant level

DISCUSSION

Our study has demonstrated that dynamic stretching treatment is more effective in improving fallen longitudinal medial arch than strengthening treatment. Dynamic stretching exercise is an effective method of increasing muscle flexibility and extensibility. Dynamic

stretching involves controlled movement through the range of motion. Dynamic stretching will help the muscles tolerate the pressure of certain activities, as well as movement patterns will help eliminate inefficient movements. In addition, the concept of flexibility will increase. Dynamic stretching can increase the temperature. This can happen when some muscles contract actively and rhythmically to stretch the muscles. Increased muscle temperature increases nerve innervation, increases contraction efficiency, and increases the response of the motor unit. In addition, increased muscle temperature will lead to reduced joint and muscle stiffness and increased glycogenesis, glycolysis and phosphate energy (Behm and Chaouachi, 2010).

Strengthening exercise refers to the ability of the contractile muscle tissue to produce tension and resultant force in the muscles that will impact the change of the medial longitudinal flow and its biomechanical changes. Strengthening exercises conducted in this study are heel raise, short foot, and squat exercise. Exercise programs such as heel raise and short foot exercise are performed to strengthen the leg muscles, especially in the intrinsic legs, anterior and posterior tibial muscles which can affect changes in the medial longitudinal arch. The squat exercise program is done to strengthen the muscles around the pelvic, thigh and knee which is one way to improve the biomechanical changes due to flat foot. However, the tension of m. gastrocnemius, m. soleus, m. hamstring, m. adductor, illiotibial band, and Achilles tendon also cause muscle imbalance. Muscle imbalance will cause the center of gravity shift to posterior, so that body alignment changes from pelvic to foot (Mosca, 2010). Pelvic will tend to spin forward while the thighs and knees will spin inward and this will cause problems with the surrounding muscles (Hermens, 2016). Dynamic Stretching given to the muscle will have the first effect on the elastin component (actin and myosin) and the muscle tension increases sharply, the sarcomere lengthens and when the muscles are continually adapted and this only lasts temporarily to gain length the desired muscle (Kisner and Colby, 2007).

Muscle mechanical response to stretching depends on myofibril and muscle sarcomeres. Each muscle is composed of several muscle fibers. One muscle fiber consists of several myofibrils. Myofibril fibers are composed of several sarcomeres that are parallel to the muscle fibers. The sarcoma is the contractile unit of myofibril and consists of overlapping actin and myosin filaments. Sarcomeres provide the muscles with the ability to contract and relax, and have the ability of elasticity when stretched. When the muscle is stretched passively, the initial elongation occurs in a series of elastic components (sarcomeres) and tension increases drastically. Then, when the strain force is released, each sarcomere will return to resting length. The tendency of the muscles to return to the resting length position after stretching is called elasticity. The neurophysiological response of muscles to stretching depends on the structure of muscle spindles and Golgi Tendon Organs (GTO). When the muscle is stretched so rapidly, the primary afferent fibers stimulate the α(alpha)-motor neurons in the spinal cord and facilitate the contraction of the extrafusal fibers that increase the tension in the muscle. This is called a monosynaptic stretch reflex. But, if stretching is done slowly on the muscles, the organ tendon stimulates stimulation and inhibits tension in the muscles thus giving elongation to the parallel elastic muscle component (Kisner and Colby, 2007). Therefore, dynamic stretching exercise is more effective to increase muscle flexibility and elasticity until improving arch longitudinal arch in flat foot rather than strengthening exercise.

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