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Flexible Flatfoot: Effects of Foot Muscle Exercises on Dynamic Balance, Plantar Pressure, and Muscle Strength

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Abstract

Background: **This study investigates the effects of tibialis posterior (TP) and peroneus longus (PL) muscle exercises with short foot (SF) exercises on dynamic balance control, plantar pressure, and TP and PL strength in individuals with flexible flatfoot.**

Methods: **This experimental study was conducted at Kasetsart University in Thailand. Twenty individuals (12 males and 8 females, aged 18−22 years) with flexible flatfoot were divided into a control group ($n = 10$) and an experimental group ($n = 10$). A control group performed the SF exercise only. The experimental group performed the TP, PL, and SF exercises. The exercise duration was 6 weeks. Both groups performed the exercises three times each week. Dynamic balance control, plantar pressure while walking, and TP and PL muscle strength were assessed before and after the 6-week exercise program.**

Results: **At the end of the 6-week period, dynamic balance control, as well as TP and PL strength, were significantly different between the two groups ($p < 0.05$); the experimental group had a better balance control and greater strength than the control group. No statistically significant between-group difference in plantar pressure was found. However, slight reductions in plantar pressure after the 6-week program were observed in the experimental group.**

Conclusions: **TP and PL exercises with SF exercises helped improve dynamic balance control and TP and PL strength, which support the medial longitudinal arch (MLA), in individuals with flexible flatfoot. In addition, exercises tended to reduce plantar pressure in individuals with flexible flatfoot.**

Keywords: Exercise, Flatfoot, Intrinsic foot muscle, Peroneus longus, Tibialis posterior

1. Introduction

Flatfoot is a foot deformity caused by the collapse of the foot arches [1]. Flatfoot affects all age groups, with a high prevalence (62%) among Thai students aged 19−22 years [1,2]. Flatfoot results in a decrease in medial longitudinal arch (MLA) height [3]. The MLA is a foot structure with key roles in distributing and supporting weight and absorbing dynamic impact forces [1]. Maintaining the MLA requires functional intrinsic foot muscles, extrinsic foot muscles, and plantar fascia. Flatfoot may also be caused by the weakness of arch-supporting muscles [4].

Deformation of the foot structure in the flatfoot leads to structural changes in the bones, muscles, and ligaments of the feet, which affect functional efficiency and balance control [5]. Previous studies have reported that individuals with flat feet have a low balance control capability when compared with individuals with normal feet [5]. A number of studies reported that flatfoot was associated with knee pain [6] and lower back pain [7]. Flatfoot was associated with increased the risk of musculoskeletal disorders in the lower extremities [8]. This condition was also a risk factor for spinal degenerative joint disease [9].

Changes in the foot structure in flatfoot not only reduces balance control, but also alters the plantar pressure distribution, and can affect health. Buldt et al. [10] reported that different foot postures cause different plantar pressure distributions. Specifically,

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individuals with flatfoot had higher peak plantar pressure and a greater contact area at the medial column when compared with individuals with normal feet and high arches [10].

Treatments for flatfoot include both surgical and nonsurgical options, with the treatment dependent on severity. Nonsurgical options can include insoles, physical therapy, or arch-supporting muscle exercises to improve balance control and plantar pressure distribution and to reduce the health risks associated with flatfoot. In a recent study, Sukprasert et al. [11] reported that functional intrinsic foot muscle exercises could increase arch heights in cases of flexible flatfoot. Kim and Kim [12] reported that short foot (SF) exercises resulted in better effects in terms of MLA improvement than insoles in individuals with flexible flatfoot. According to a number of studies, the exercises not only improved foot posture but also improved balance in individuals with flexible flatfoot [12,13]. Lee and Choi [14] revealed that intrinsic foot muscle and tibialis posterior (TP) strengthening exercises improved plantar pressure distribution in individuals with flexible flatfoot while standing still.

Most previous studies have focused on SF exercises to increase muscle strength [12,13]. These types of exercises focus only on abductor hallucis activation and the function and strengthening of the intrinsic foot muscles. However, the maintenance of the MLA also depends on the extrinsic foot muscles. According to previous research, TP muscle activity is increased in people with flatfoot because the MLA has to support excessive weight compared with normal feet [4]. Thus, more TP activity is required to maintain the MLA. Decreased peroneus longus (PL) activity was also found in those with flatfoot, which affected MLA maintenance [4]. Consequently, the strength of the muscles that play a role in maintaining the MLA is another important factor that causes flatfoot. However, there have been few studies on exercises to strengthen extrinsic foot muscles (i.e., TP and PL) that help support the MLA in individuals with flexible flatfoot [14,15]. Therefore, the aim of this study was to investigate the effects of TP and PL exercises, together with SF exercises, on dynamic balance control, plantar pressure, and TP and PL strength in individuals with flexible flatfoot.

2. Methods

2.1. Study design and participants

This experimental study was conducted from February 2022 to August 2022 at the Faculty of Sports Science, Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom, Thailand. The study population comprised 20 students (12 males and 8 females) with flexible flatfoot. The desired sample size was calculated using G*Power 3.1.9.4, with the significance level at 0.05 ($\alpha = 0.05$), effect size = 0.523 [16], and power: 1-β = 0.95.

The inclusion criteria were males and females aged between 18 and 25 years with flexible flatfoot and a foot posture index (FPI) of > +5 [17], arch height index (AHI) of <0.31 [18], and body mass index (BMI) of 18.5–22.9 kg/m^2. Individuals with physical deformities affecting movement and posture, and those using insoles or mobility aids were excluded. Additional exclusion criteria were ankle/foot pain or injuries in the past 6 months, back/lower extremity injuries or surgery, diabetes, or hypertension, and a leg length difference of >1.1 cm [19].

The participants were randomized into two groups based on AHI, sorted from less to more. Every two participants were classified into different groups: 1) a control group (n = 10, 6 males and 4 females) performed the SF exercise, and 2) an experimental group (n = 10, 6 males and 4 females) performed the TP and PL exercises and the SF exercise.

All participants were notified about the study procedures and signed an informed consent form to participate in the study.

2.2. Measurements

All tests were performed before and after the 6-week exercise program. The participants were tested as follows:

2.2.1. Dynamic balance control test

Dynamic balance control was tested using PosturoMed (HaiderBioswing GmbH, Pullenreuth, Germany). This instrument was set to detect the movements (CMS10, Zebris Medical GmbH, Isny im Allgäu, Germany) of the PosturoMed plate. The instrument was placed on the side of the PosturoMed. All participants were barefooted and were instructed to stand still on the plate. The plate lock was suddenly released without warning [20]. After that, the participants had to try to control their balance until the plate stopped [20]. The total sway distance was recorded (mm).

2.2.2. Plantar pressure test while walking

Plantar pressure while walking was tested using a zebris FDM-T (zebris Medical GmbH, Isny im Allgäu, Germany) at a sampling rate of 100 Hz and SYNCLightcam (zebris Medical GmbH, Isny im

Allgäu, Germany). The participants walked with their bare feet, selecting the speed they encountered during daily activities of living. Peak plantar pressure data (N/cm^2) were recorded for 30 s.

2.2.3. Tibialis posterior (TP) and peroneus longus (PL) muscle strength tests

The strength of the TP and PL muscles was tested using a wireless muscle strength tester (Tracker™ Version 5, JTECH Medical, Utah, USA). The intra-tester reliability of the tester was high (ICC = 0.805−0.897). In the muscle strength tests, resistive force was measured in a fixed direction during the maximum isometric contraction (kg). Each muscle was tested three times and held for 5 s each time, with a 5-s rest before the next measurement. The maximum force data were selected. For the TP, muscle strength tests were measured by placing the wireless tracker's dynamometer on the medial side of the first metatarsal. The participants were then instructed to push as hard as they could in the direction of inversion and plantar flexion measurements. The PL muscle strength tests were measured by placing the wireless tracker's dynamometer on the lateral side of the fifth metatarsal. The participants were instructed to push as hard as they could in the direction of the eversion and dorsiflexion measurements.

2.3. Exercise intervention

Both groups performed the exercises three times a week for 6 weeks. In the control and experimental groups, the SF exercise intervention was performed for 13 min, including rest time between sets. In the experimental group, the exercise intervention consisting of TP and PL exercises was performed for 36, 39, and 42 min including rest time between sets for weeks 1 and 4, 2 and 5, and 3 and 6, respectively. The exercise intervention time varied according to the number of repetitions specified in Table 1. Rest time between sets for all exercises was 2 min.

2.3.1. Short foot (SF) exercises

The participants performed the exercise while sitting on a chair. They curled their feet by moving their forefoot toward their heels and raising up the arch curve. The participant performed the foot exercise using one foot, and then the other foot 10 times per set. Each time was held for 5 s. In total, there were three sets, with a 2-min rest between sets. Every 2 weeks the position of the exercise was changed from a sitting to a standing to a single leg stance position. This regimen was adapted from a study by Mulligan and Cook [13].

Table 1. Tibialis posterior (TP) and peroneus longus (PL) muscle exercise program with elastic bands performed by experimental group.

Week	Intensity	Repetitions	Sets
1	70% of maximum ISOM force	8	3
2	70% of maximum ISOM force	10	3
3	70% of maximum ISOM force	12	3
4	80% of maximum ISOM force	8	3
5	80% of maximum ISOM force	10	3
6	80% of maximum ISOM force	12	3

Note(s): Modified from the American College of Sports Medicine [21]; ISOM = isometric contraction.

2.3.2. Tibialis posterior (TP) and peroneus longus (PL) exercises

In the muscle exercises, participants used colored elastic resistive force bands (TheraBand® Hygenic, Ipoh, Malaysia). Each color provided different resistive forces. At 100% elongation, the blue, black, silver colored elastic bands had resistances of 5.8, 7.3, and 10.2 lbs., respectively. The resistive force of the elastic bands was based on the maximum isometric contraction force achieved in the muscle strength test (Table 1). The exercise included the following postures:

Foot adduction: The participant sat on a banquet chair with a height from floor to seat of 46 cm. The foot movement points were in a V shape at 45°, with the heel as the rotation spot. Each participant wore an elastic band on the forefoot at the same level as the metatarsal. The participant then moved the foot by resistive force to foot adduction and held the position for 5 s.

Foot inversion: The participant sat on a chair. The practiced leg was stretched straight, and the knee was not flexed. The participant wore an elastic band on the forefoot at the same level as the metatarsal. The participant then moved the foot, with resistive force to foot inversion, and held the position for 5 s.

Single heel raises: The participants stood still with their hands on their hips. The elastic band was in the middle of the foot and anchored laterally, with tension away from the body. The participant then stood on the tips of their toes, raising their heels, with the knee maintained in full extension. This posture was held for 5 s.

2.4. Statistical analysis

The Statistical Package for the Social Sciences (SPSS) for Windows Version 22 (IBM Corp., Armonk, NY, USA) was used for the data analysis. Descriptive analysis of the data was presented as the mean ± standard deviation. Between-group and within-group comparisons of the data (mean ± standard deviation) from the dynamic balance control, plantar pressure, and TP and PL strength tests in both groups were conducted before and after the exercises (week 6). The data were compared using a two-way repeated measures analysis of variance test with a significance level of 0.05 ($p < 0.05$).

2.5. Ethical considerations

This study was approved by the Kasetsart University Research Ethics Committee (COA65/003) and the Thai Clinical Trials Registry (TCTR ID:TCTR20221219001).

3. Results

The baseline demographic and foot characteristics data for the control group (mean ± standard deviation) were as follows: average age = 19.40 ± 1.43 years, average weight = 58.40 ± 8.69 kg, average height = 1.65 ± 0.08 m, average BMI = 21.14 ± 1.35 kg/m^2, average foot posture index (FPI) = 8.90 ± 1.66 points, and arch height index (AHI) = 0.27 ± 0.02. In the experimental group, the demographic and foot characteristics data (mean ± standard deviation) were as follows: average age = 19.30 ± 1.16 years, average weight = 58.24 ± 10.16 kg, average height = 1.69 ± 0.11 m, average BMI = 20.23 ± 1.07 kg/m^2, average FPI = 8.70 ± 1.63 points, and AHI = 0.27 ± 0.02. According to the between-group comparison before the 6-week exercise program, there were no significant differences in the age, weight, height, BMI, FPI, and AHI among the participants in the control group compared to the experimental group ($p > 0.05$).

3.1. Dynamic balance control

Comparison of dynamic balance control between the control group and the experimental group before the 6-week exercise program revealed no significant difference ($p > 0.05$). However, after the exercise program, there was a significant difference in dynamic balance control between the two groups ($p < 0.05$); the experimental group had more dynamic balance control than the control group. Further, no significant difference was found between the dynamic balance control before and after the 6-week exercise program in the control group ($p > 0.05$), whereas there was a significant difference before and after the exercise program in the experimental group ($p < 0.05$) (Table 2). The differences in sway distance, which is a measure of dynamic balance control, before and after 6-week exercise program in the experimental group are presented in Fig. 1. There were smaller sway

Table 2. Between and within group comparisons of dynamic balance control, plantar pressure, and muscle strength among the experimental and control groups.

Variable	Control group		Experimental group		Between group p-value
	Before	After	Before	After	
Dynamic balance control (mm)	183.35 ± 56.09	180.33 ± 27.11	201.62 ± 43.31	152.19 ± 26.76	0.426§, 0.031$^{\|\|}$*
p-value	0.190†		<0.001‡*		
Plantar pressure (N/cm^2)					
Medial forefoot	30.10 ± 5.66	30.02 ± 4.68	33.60 ± 8.07	30.86 ± 5.57	0.414§, 0.414$^{\|\|}$
p-value	0.418†		0.418‡		
Lateral forefoot	24.31 ± 5.14	25.21 ± 5.41	22.60 ± 5.11	22.40 ± 4.97	0.053§, 0.053$^{\|\|}$
p-value	0.346†		0.346‡		
Medial midfoot	14.77 ± 3.27	14.70 ± 3.67	16.34 ± 5.18	15.17 ± 5.64	0.430§, 0.827$^{\|\|}$
p-value	0.357†		0.080‡		
Lateral midfoot	18.95 ± 5.43	17.50 ± 4.00	17.03 ± 4.66	16.58 ± 5.09	0.504§, 0.504$^{\|\|}$
p-value	0.863†		0.863‡		
Medial heel	22.60 ± 6.16	24.70 ± 6.84	25.00 ± 6.32	25.76 ± 7.48	0.840§, 0.840$^{\|\|}$
p-value	0.186†		0.388‡		
Lateral heel	20.20 ± 4.58	20.92 ± 5.62	21.53 ± 3.96	21.38 ± 4.31	0.838§, 0.838$^{\|\|}$
p-value	0.341†		0.341‡		
Muscle strength (kg)					
TP	13.06 ± 1.05	13.49 ± 0.73	13.21 ± 0.86	14.56 ± 1.01	0.731§, 0.014$^{\|\|}$*
p-value	0.127†		<0.001‡*		
PL	12.62 ± 0.71	12.71 ± 0.80	12.76 ± 0.81	14.43 ± 1.07	0.688§, 0.001$^{\|\|}$*
p-value	0.424†		<0.001‡*		

Note(s): Values are presented as mean ± standard deviation; TP = tibialis posterior; PL = peroneus longus; * = significant difference at $p < 0.05$; † = comparison in control group before and after the 6-week exercise program; ‡ = comparison in experimental group before and after the 6-week exercise program; § = comparison between-group before the 6-week exercise program; $^{\|\|}$ = comparison between-group after the 6-week exercise program.

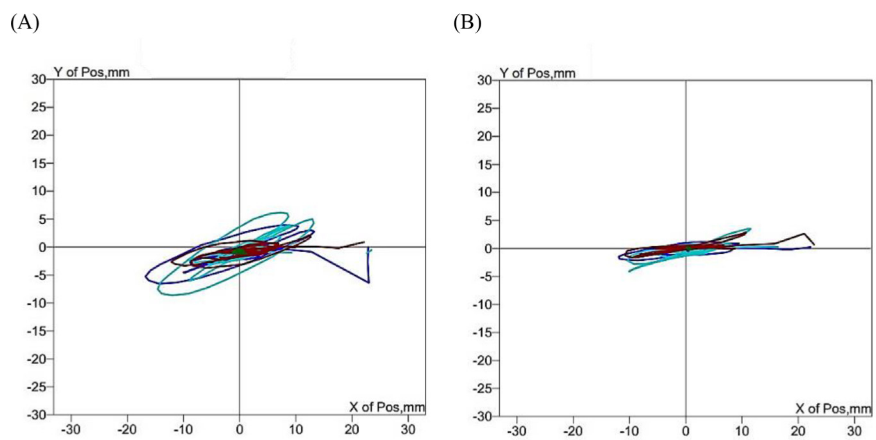

Fig. 1. Sway distance (measure of dynamic balance control) in the experimental group: (A) before and (B) after the 6-week exercise program.

distances in the experimental group after compared to before completion of the 6-week program, which indicated improved dynamic balance control.

3.2. Plantar pressure

Comparison of the difference in plantar pressure in six areas (medial forefoot, lateral forefoot, medial midfoot, lateral midfoot, medial heel, and lateral heel) while walking before and after the 6-week exercise program in the control group and experimental group revealed no significant difference ($p > 0.05$). There was also no significant difference in plantar pressure in the six areas while walking before and after the 6-week exercise program in either the control group or the experimental group ($p > 0.05$) (Table 2). A comparative representation of the peak plantar pressure before and after the 6-week exercise program in the experimental group is shown in Fig. 2. There were slight decreases in peak plantar pressure for the medial forefoot and medial midfoot before compared to after the exercise program in the experimental group; but differences were not statistically significant.

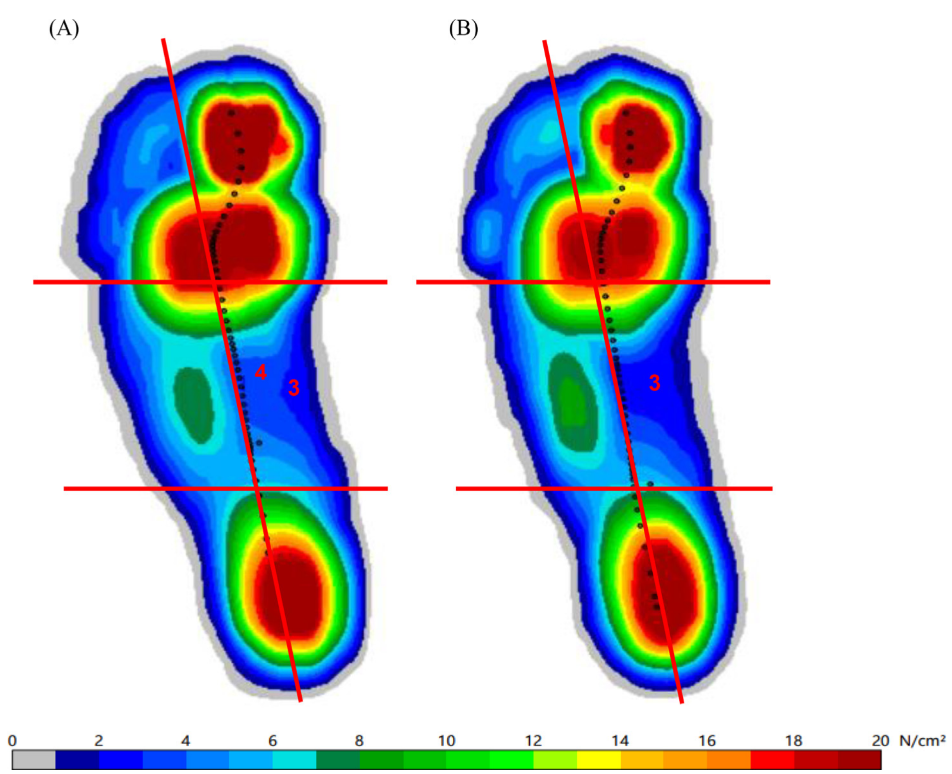

Fig. 2. Peak plantar pressure during walking in the experimental group: (A) before and (B) after the 6-week exercise program.

3.3. Tibialis posterior (TP) and peroneus longus (PL) muscle strength

There was no significant difference in TP and PL strength in the control group versus in the experimental group before the 6-week exercise program ($p > 0.05$). However, there was a significant between-group difference in TP and PL strength after the 6-week exercise program ($p < 0.05$); the experimental group had greater TP and PL strength than the control group. The difference in TP and PL strength before and after the 6-week exercise program in the control group was not significant ($p > 0.05$), whereas, there was a significant difference in the experimental group ($p < 0.05$) (Table 2). The differences in TP and PL strength before and after the 6-week exercise program in the experimental group are presented in Fig. 3. We found higher forces for foot inversion and foot eversion after compared to before the exercise, which indicated greater TP and PL strength.

4. Discussion

4.1. Dynamic balance control

After the 6-week exercise program, we found improved dynamic balance control in the experimental group compared to the control group. After the program, the mean sway distance, which measured dynamic balance control, in the experimental group was shorter than that in the control group. This implied better dynamic balance control capability (Fig. 1). Dynamic balance control is required to stabilize the body on unstable and stable surfaces [22]. Balance control in healthy adults depends on somatosensory information from the surfaces that the feet contact [23], which provides information about the position and movement of the body. In a similar previous study of adults with flexible flatfoot, Lee and Choi [14] reported that intrinsic foot muscle and TP strengthening exercises (5 days a week for 6 weeks) resulted in a higher improvement in dynamic balance ability than intrinsic foot muscle strengthening exercises only. Similarly, Panichawit et al. [15] reported that foot muscle exercises reduced pain and difficulty of the foot in individuals with flexible flatfoot. Pain and difficulty of the foot was assessed using a foot function questionnaire containing 10 items in which respondents reported their level of pain while standing and walking.

Muscle strengthening exercises not only affect the adaptation of tissues but also of the nervous system, resulting in improved somatosensory and motor output of the lower extremities through better function neuromuscular control [24]. In the present study, the sway distance in the experimental group was reduced due to dynamic balance control, as shown by the PosturoMed device. Therefore, in our

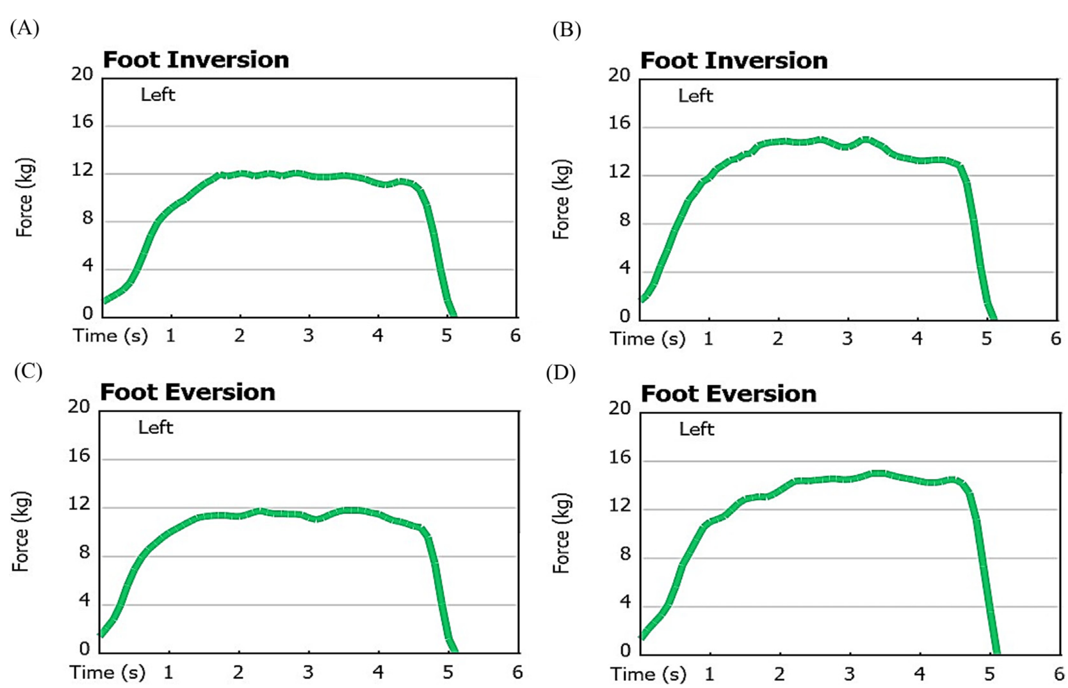

Fig. 3. Maximum force of tibialis posterior (TP) muscle in the experimental group: (A) before and (B) after the 6-week exercise program; maximum force of peroneus longus (PL) muscle: (C) before and (D) after the 6-week exercise program.

study, activating the TP and PL by exercising improved dynamic balance control. However, the control group that received the short foot exercise only did not show significant changes in dynamic balance control. In contrast, other previous studies found that short foot exercises improved dynamic balance control in people with flatfoot [12,13]. This may be because of the method used in the tests. In past studies, Y balance tests [12] and star excursion balance tests [13] were used, which are typically performed on a stable surface. However, in this study, the PosturoMed device was used to evaluate the dynamic balance control on unstable surfaces caused by sudden perturbation, thereby making balance control more difficult, which requires the strength of the intrinsic foot muscle and extrinsic foot muscle (TP and PL) to control the stability of the body while the support surface is moving, especially movements in the mediolateral direction, requiring activation of the invertors and evertors muscle group.

4.2. Plantar pressure

In our study, there was no difference in peak plantar pressure while walking for the experimental versus the control group after the 6-week exercise program in any of the six areas measured (medial forefoot, lateral forefoot, medial midfoot, lateral midfoot, medial heel, and lateral heel). However, in the experimental group, mean peak plantar pressure on the medial forefoot and medial midfoot decreased while walking by 8.15% and 7.15%, respectively, after the 6-week exercise program. Previous studies on the association of plantar pressure with foot posture reported that individuals with flexible flatfoot had higher medial forefoot and medial midfoot plantar pressures than those with normal feet [10]. Panichawit et al. [15] reported no significant difference in the effects of 8-week foot muscle exercises on plantar pressure during walking in a sample with flexible flatfoot. Although the contact area in the medial midfoot was slightly reduced after the exercise program among our study's participants, the finding was not statistically significant. In contrast to our study, Unver et al. [16] reported that a 6-week program of SF exercise led to an increase in plantar pressure during walking in the midfoot in individuals with flexible flatfoot.

The results of this study showed that the peak plantar pressure on the medial forefoot and medial midfoot decreased (8.15% and 7.15%) after 6-week exercise in the experimental group. These findings imply that exercising muscles that support the MLA could help reduce plantar pressure during walking in individuals with flexible flatfoot (Fig. 2). A reduction in plantar pressure was caused by the stronger MLA supportive muscles, particularly the TP and PL. The TP and PL help prevent the collapse of the arch and keep the arch springy during walking, which results in increased weight bearing. As a result, the alignment of the foot structure changed, with joint stability increasing. In agreement with our findings, Imhauser et al. [25] stated that the tendons of the TP lock hind foot bones and arch bones in the sagittal plane and transverse plane in a stable configuration that resists arch collapse. The insertion of the PL is at the base of the first metatarsal and medial cuneiform, which provides major support for the arches of the foot, adjustment of the foot to the ground, and control of the leg on the planted foot while walking [26]. In a previous study, pulling of the PL tendon improved first metatarsal subluxation [27] and reduced foot stiffness [28].

4.3. TP and PL strength

In the present study, TP and PL strength improved after the 6-week exercise program; mean muscle strength in the experimental group was higher than that in the control group. In addition, in the experimental group, mean TP and PL strength after the 6-week exercise program were higher than before the program (Fig. 3). The experimental group performed the same SF exercise as the control group. But the experimental group performed TP and PL exercises which were not performed by the control group. These extra exercises included foot adduction, foot inversion, single heel raise, and TheraBand exercises (Table 1). Kulig et al. [29] reported that three postures (foot adduction, foot inversion, and single heel raise) activated the TP and PL muscles. In a magnetic resonance imaging study, these three postures increased the signal intensity of the TP by 50%, 26%, and 27%, respectively. The heel raise increased the signal intensity of the PL by 57%. These results were similar to those of a study by Panichawit et al. [15], who reported that an 8-week program of foot muscle exercises increased TP and PL strength. In previous studies, the results of strengthening exercises were seen within the first 4–8 weeks of exercise commencement [21]. The TP and PL exercise program in the present study was only 6 weeks. Our results revealed within-group and between-group changes in TP and PL strength. The results of the present study imply that TP and PL exercises with SF exercise for 6 weeks are sufficient to improve TP and PL strength in individuals with flexible flatfoot. The changes were likely caused by the neuromuscular system response to resistance exercise. In response to exercise, there was increased motor unit recruitment and the size of the cross-sectional area of the muscle, which lead to structural muscle changes.

4.4. Overall

The results of this study suggest that TP and PL strength influence dynamic balance control in individuals with flexible flatfoot. The TP and PL are extrinsic foot muscles with an insert on the plantar of the foot. Therefore, stronger TP and PL contribute to the enhancement of sensory input via muscle proprioceptors that detect changes in the length and tension of the muscles during perturbation. Additionally, the anatomical position and alignment of the TP that passes under the medial malleolus and the PL that passes under the lateral malleolus allow more effective control of the ankle joint, resulting in an increased ability for dynamic balance control. Similarly, Mulligan and Cook [13] reported that the efficiency of dynamic balance control improved subtalar joint control via increased awareness and control of the TP and peroneus muscle groups.

In this study, the intrinsic foot muscle exercises, together with the TP and PL exercises, resulted in an improvement in the supportive structure of the MLA while moving by elevating the MLA to prevent excessive collapse of the foot arches, which affects balance control in the flexible flatfoot. We observed that TP and PL exercises with SF exercise three times a week for 6 weeks were sufficient to improve dynamic balance control capability in individuals with flexible flatfoot. There was more improvement seen in the experimental group than in the control group that performed SF exercise only (intrinsic foot muscle exercise). Based on the findings of our study and the reasons above, it is also possible that TP and PL exercises without SF exercise can improve dynamic balance control in individuals with flexible flatfoot.

4.5. Limitations and suggestions

One limitation of this study is that the devices used to assess plantar pressure that could not measure the contact area. Measurements of the contact area could have provided valuable information about exercise-induced changes in foot shape. Furthermore, future studies should include measurements of the MLA to demonstrate their association with changes in plantar pressure.

5. Conclusions

The results of this study revealed that TP and PL exercises with SF exercises can help improve dynamic balance control and the strength of the muscles that support the MLA. Although the differences were not statistically significant, we observed some potential decreases in plantar pressure on the medial forefoot and medial midfoot in individuals with flexible flatfoot that performed TP and PL exercises with SF exercise compared to the SF exercise only. Therefore, the program in this study can be a guideline for selecting exercise programs to improve dynamic balance control, as well as TP and PL strength, in people with flexible flatfoot. In addition, health care providers can provide recommendations on how to take care of people with flexible flatfoot.

Conflict of Interest

None.

Acknowledgments

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