J Int Acad Phys Ther Res 2019; 10(4): 1934~1939
ISSN 2092-8475

www.iaptr.org
https://doi.org/10.20540/JIAPTR.2019.10.4.1934

Effects of Visual Feedback Short Foot Exercise on Foot Pressure in Adults with Flexible Flat Foot

Background: Flexible flat foot is that the medial longitudinal arch collapses in weight bearing and returns normal arch when weight is removed and the weight bearing shifts toward medial part of the foot, which can cause pathological problems in the alignment of the lower extremities and the entire body.
Objective: To compare the foot pressure for adults with flexible flat foot.
Design: Quasi-Experimental Study
Methods: 24 participants with flexible flat foot were recruited and were randomly divided into Visual feedback Short Foot Exercise (VSFE) group and Short Foot Exercise (SFE) group. To compare changes of foot pressure about pre and post intervention, the contact pressure measurement was conducted.
Results: In the VSFE, significant differences were observed for the foot pressure of the 1st toe, 1st, 3rd and 4-5th metatarsal, midfoot, medial and lateral heel ($p<.05$). The foot pressure of the 3rd and 4-5th metatarsal, midfoot showed significant differences in the SFE ($p<.05$). The contact pressure of the 1st toe, 3rd metatarsal showed significant differences between the groups.
Conclusions: Visual feedback short foot exercise can be useful for moving the pressure from medial to lateral part, and can prevent possible pathological problems.

Key words: *Visual feedback; Short foot exercise; Flexible flat foot; Foot pressure*

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Received : 17 September 2019
Revised : 25 October 2019
Accepted : 28 October 2019

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INTRODUCTION

Flexible flat foot is a common condition and the characteristics of it are collapsing the medial longitudinal arch in the weight bearing stance, resulting in excessive foot pronation.[1] It includes compensated forefoot abduction and rear foot valgus, as contributing the muscle imbalance, ligamentous laxity and weight bearing shift toward medial part of the foot.[2] During the latter half stance phase in walking, people who have flexible flat foot does not show subtalar joint inversion and the talus dorsiflexion, it makes foot and lower leg fatigue.[3,4] It is important to treat the flexible flat foot with appropriate intervention before being severe state to prevent disease progression, preserve function and minimize surgical treatment.[5]

In case of flat foot, the intrinsic foot muscles are atrophied compared with normal foot and the extrinsic foot muscles show more activation.[6] As the primary task of intrinsic foot muscles is to support and stabilize the medial longitudinal arch, the imbalances of these muscles affect the plantar pressure and change the alignment of the whole body, as well as the deformities of ankle and toes.[7,8] The high contact pressure of the foot is a critical risk factor about callus, deformities and plantar tissue thickness.[9]

Among a variety of strengthening exercise methods of the intrinsic foot muscles, short foot exercise is well used because it can strengthen intrinsic foot muscles except extrinsic foot muscles.[10] The short foot exercise is what makes foot small and narrow by contracting the intrinsic foot muscles and increases afferent sensory input from the soles.[11] And biofeedback

exercise is a common and effective factor to make specific movement and muscle activation.[12] The central nervous system relies on sensory input form receptors in the lower extremities to generate effective motor patterns for posture and locomotion.[13]

Previous studies approved the effects of the short foot exercise on navicular drop, balance and plantar pressure also. However, there is no study yet on the effects of the short foot exercise with visual feedback on foot pressure changes. Therefore, the aim of this study is to compare the effects of short foot exercise with and without visual feedback on foot pressure in adults with flexible flat foot. Another is to suggest that the Mat scan® system can be used as visual feedback. The hypothesis of this study is that the short foot exercise with and without visual feedback will have differences in foot pressure within group and between groups.

SUBJECTS AND METHODS

Subjects

The subjects of this study were 24 adults. The detailed selection criteria were as follows.

1) Those who tested positive of Feiss line test
2) Those who had no orthopedic surgery or treatment on lower extremity before
3) Those who did not have visual field defect and vestibular disorders
4) Those who have not recently performed continuous muscle strengthening

All subjects were fully informed about the purpose and methods of this study and voluntarily agreed to participate in this study. This study was approved by the Bioethics Committee of Daegu University(No. : 1040621-201702-HR-029-02).

Experimental design

The 24 subjects who tested positive of Feiss line test were selected. The Feiss line test is considered to be a positive test for flexible flat foot if the line between the medial malleolus and the first metatarsophalangeal joint is drawn without the weight load and the mark of the navicular drops down from the line. [14] And physical measurements and navicular drop length were carried out to identify the general characteristics of the subjects. They were randomly divided into 2 groups; visual feedback short foot exercise (VSFE, n=12) group and short foot exercise (SFE, n=12) group. Both groups were equally performed under same condition except of visual feedback: 50 minutes a session, 5 times a week, for 6 consecutive weeks. To compare the differences of effects, the foot pressure of dominant foot in all subjects was evaluated. The contact pressure of foot was measured using the Mat scan® system (TekScan Inc., South Boston, MA, USA) for the baseline assessment of foot pressure (Figure 1).

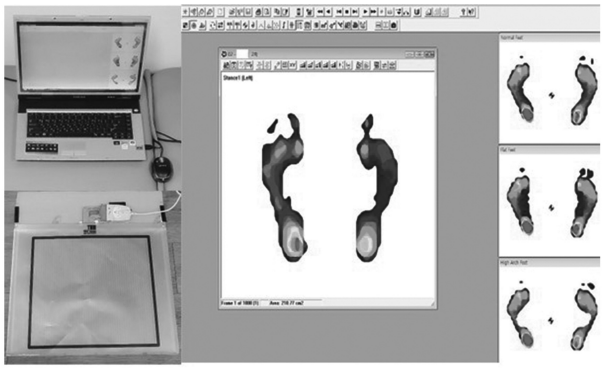

Fig. 1. Mat scan® system

Exercise Methods

Short foot exercise group

The short foot exercise is shortening the length of the foot as the intrinsic foot muscles contract, while making medial longitudinal arch and pushing 5 metatarsal heads. The short foot exercise was performed both the dominant and non-dominant foot. The subjects performed short foot exercise in sitting, standing, one leg standing position during whole exercise period. Additionally, on 1~2 weeks, standing in a line and weight shift were performed maintaining short foot posture. On 3~4 weeks, motions of upper and lower extremities were added. And on 5~6 weeks, squat and lunge were performed.

Visual feedback short foot exercise group

For real-time visual feedback to VSFE, Mat scan® system that is the same as measurement tool was used. Before exercise, subjects made the short foot position on mat by looking at the monitor and maintained the pressure during exercise. The other conditions were same.

Data

The foot pressure of all subjects was measured using mat scan® system and foot pressure data was taken to compare the differences of foot pressure.

Statistical analysis

All the data were analyzed with SPSS 23.0 ver for windows (SPSS Inc, Chicago, IL). Means and standard deviation of the general characteristics and variables of the subjects were calculated and Shapiro-wilks test was used for normality. To confirm the difference in foot pressure before and after each group exercise, paired t-test was conducted. To confirm the difference between groups, independent t-test was conducted. The statistical significance level was set to α=.05.

RESULTS

The homogeneity test showed that the two groups were homogeneous because there were no significant differences (p>.05) (Table1).

In the visual feedback short foot exercise group, significant differences (p<.05) were observed for the foot pressure of the 1st toe, 1st, 3rd and 4-5th metatarsal, midfoot, medial and lateral heel and contact area of the midfoot.

The foot pressure of the 3rd and 4-5th metatarsal, midfoot and contact area of the midfoot showed

Table 1. General characteristics of subjects

	VSFE [a]	SFE [b]	t	p
Gender (M/F)	6 / 6	6 / 6		
Age (years)	22.66 ± 0.98c)	23.50 ± 1.97	-1.30	.20
Height (㎝)	167.09 ± 7.92	168.25 ± 9.15	-.33	.74
Weight (㎏)	66.18 ± 13.20	65.69 ± 17.30	.07	.93
Navicular drop test (㎜)	12.83 ± 4.10	12.50 ± 2.61	.23	.81

[a],VSFE: Visual feedback short foot exercise group [b],SFE: Short foot exercise group [c],Mean ± standard deviation, p < .05

Table 2. The comparison of fore foot contact pressure (unit : ㎪)

Area	Group	Pre	Post	Difference value	t	p
Hallux	VSFE [a]	23.83 ± 8.09 [c]	12.91 ± 5.82	-10.91 ± 10.32	3.66	.00*
	SFE [b]	19.75 ± 8.44	19.25 ± 6.28	-0.50 ± 6.59	.26	.79
	t	1.20		-2.94		
	p	.24		.00*		
1st metatarsal	VSFE	27.25 ± 8.36	20.50 ± 8.01	-6.75 ± 7.55	3.09	.01
	SFE	21.16 ± 8.58	22.41 ± 11.48	1.25 ± 13.52	-.32	.75
	t	1.75		-.14		
	p	.09		.09		
2nd metatarsal	VSFE	25.58 ± 5.50	29.91 ± 6.80	4.33 ± 8.45	-1.77	.10
	SFE	23.50 ± 12.26	25.33 ± 12.70	1.83 ± 8.88	-.71	.48
	t	.53		.70		
	p	.59		.48		
3rd metatarsal	VSFE	27.25 ± 5.47	38.41 ± 6.05	11.16 ± 6.26	-6.17	
	SFE	26.58 ± 5.05	28.75 ± 4.76	2.16 ± 3.29	-2.27	
	t	.31		4.40		
	p	.76		.00*		
4-5th metatarsal	VSFE	24.41 ± 9.78	34.00 ± 9.73	9.58 ± 6.18	-5.36	
	SFE	23.50 ± 8.20	32.58 ± 9.73	9.08 ± 9.02	-3.48	
	t	.24		.15		
	p	.80		.87		

[a],VSFE: Visual feedback short foot exercise group [b],SFE: Short foot exercise group [c],Mean ± standard deviation, * p<.05

Table 3. The comparison of mid foot contact pressure (unit : kPa)

Group	Pre	Post	Difference value	t	p
VSFE [a]	21.75 ± 7.60 [c]	29.08 ± 4.83	7.33 ± 6.54	−3.88	.00*
SFE [b]	19.16 ± 6.39	24.33 ± 7.72	0.50 ± 6.59		.00*
t	.90		.91	−3.61	
p	.37		.37		

[a],VSFE: Visual feedback short foot exercise group [b],SFE: Short foot exercise group [c],Mean ± standard deviation, * p<.05

Table 4. The comparison of rear foot contact pressure (unit : kPa)

Area	Group	Pre	Post	Difference value	t	p
Medial part	VSFE [a]	73.16 ± 15.90[c]	59.75 ± 13.84	−13.41 ± 14.63	3.17	.00*
	SFE [b]	68.58 ± 10.81	64.25 ± 14.47	−4.33 ± 18.42	.81	.43
	t	.82		−1.33		
	p	.41		.19		
Lateral part	VSFE [a]	52.58 ± 11.86	64.50 ± 15.04	11.91 ± 4.58	−9.01	. 00*
	SFE [b]	58.25 ± 9.49	68.66 ± 14.03	10.41 ± 20.37	−1.77	.10
	t	−1.29		.24		
	p	.21		.80		

[a],VSFE: Visual feedback short foot exercise group [b],SFE: Short foot exercise group [c],Mean ± standard deviation, * p<.05

significant differences (p<.05) in the short foot exercise group. The contact pressure of the 1st toe, 3rd metatarsal and the contact area of the midfoot showed significant differences between the groups (p<.05) (Table2−4).

DISCUSSION

As the characteristics of flexible flat foot in weight bearing are the lowered medial longitudinal arch, forefoot abduction and rear foot valgus, the foot pressure is high in medial part of the foot. These deformities lead to pathologic problems, therefore, proper treatment is important before being severe state. This study was conducted to compare the changes of foot pressure before and after short foot exercise with and without visual feedback.

In case of normal foot, the second and third metatarsal area among the forefoot is subject to the greatest load.[15] The results of this study were that the pressure of hallux area decreased and 3rd metatarsal area increased significantly in visual feedback short foot exercise group and there were significant differences between groups. But the short foot exercise group did not show the differences on hallux. Similar to the results of this study, a study reported that the foot pressure of hallux area decreased and the 2nd−3rd metatarsal area increased after short foot exercise.[16] And other study about the short foot exercise with EMG biofeedback showed increasing activation of abductor halluces.[17] It is regarded that the visual feedback short foot exercise activates the abductor halluces properly and moves pressure from medial to lateral part of the foot. Even the short foot exercise group also showed the moving pressure, the differences of medial foot pressure were not significant. The visual feedback short foot exercise group was able to confirm the pressure with monitor in real−time, but the short foot exercise group was not. So, the short foot exercise group had lacked delicate control.

The flat foot almost touches the floor as medial longitudinal arch is lower than normal.[18] In the comparison of midfoot pressure, both groups showed significant increase and visual feedback short foot exercise group was greater than the other group. But, there was no significant difference between groups. Several studies showed the short foot exercise improved the navicular position.[19,20] As the short foot exercise is to form medial longitudinal arch, the contact area of

midfoot decreased and contact pressure increased. This result is able to support a research, the short foot exercise reduced the difference in the height of the navicular bone in weight and removed weight.[21]

In this study, the rearfoot was divided into medial and lateral parts. The visual feedback exercise group showed that the pressure of medial part decreased and lateral part increased, but there were no significant effects between groups. It is regarded that the load is shifted from medial to lateral part of the foot and short foot exercise with visual feedback is more effective than the other.

Several studies approved the effects of short foot exercise on navicular position and balance, but there were not enough studies about short foot exercise and there was no study about effects of visual feedback short foot exercise on foot pressure. A study reported that there were no significant effects of the low-dye taping and short foot exercise on foot pressure in flexible flat foot.[22] This study approves short foot exercise can move the foot pressure from medial to lateral part. Although differences between the two groups appeared in part, there were more effective in visual feedback short foot exercise group.

There were several limitations in the present study. It was difficult to generalize the study results due to the small number of subjects. In addition, the assessment was only dominant foot. For the future study, more subjects and both foot will be applied in order to determine and compare the effects of the exercises.

CONCLUSION

In conclusion, this study suggests that visual feedback short foot exercise can be useful for moving the pressure from medial to lateral part, as making the medial longitudinal arch, in flexible flat foot, and can prevent possible pathological problems.

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