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The Influence of Pelvic Adjustment on Functional Leg Length Inequality and Foot Pressure

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Abstract. [Purpose] This study was conducted to evaluate the influence of pelvic adjustment on functional leg length inequality (FLLI) and foot pressure. [Subjects] The study subjects were 40 adults who were healthy but had FLLI of at least 10 mm. Subjects were randomly assigned to two groups, an experimental group (n=20) and a control group (n=20). [Methods] The subjects of the experimental group underwent pelvic adjustment 3 times a week for 4 weeks. A tape- measure was used to measure FLLI, and F-Scan was used to measure the heel pressure difference (HPD) and the 1st metatarsal pressur difference (MPD). For all subjects, the lengths of both legs were measured before the intervention, and at 2 weeks and 4 weeks after the intervention was started. [Results] Pelvic adjustment was effective at reducing FLLI , HPD and 1st MPD. HPD and the 1st MPD were reduced in proportion to the reduction in FLLI . FLLI was effectively reduced after 2 weeks of intervention and the reduction was more remarkable after 4 weeks. [Conclusion] We presume that pelvic adjustment reduces FLLI and foot pressure difference and that foot pressure difference is reduced in proportion to the reduction in FLLI. In conclusion, we consider that pelvic adjustment is suitable for reducing FLLI as well as foot pressure difference.
Key words: Foot pressure, Functional leg length inequality, Pelvic adjustment

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INTRODUCTION

'Leg length inequality (LLI)' means that both legs are markedly different in length[1)]. Ground reaction force of the long leg is significantly different from that of the short leg in the maximum vertical force, the maximum medial force and the maximum lateral force[2)]. Han et al.[3)]. reported that the center of foot pressure (COP) carries an important meaning biomechanically and LLI affects foot pressure. Ordinarily, LLI is classified as functional leg length inequality (FLLI) and structural leg length inequality (SLLI)[4)]. It is presumed that SLLI arises due to bones of different lengths, but FLLI arises due to contraction of the lower limbs[5)]. Lateral pelvic inclination in the saggital plane or pelvic torsion in the coronal plane abducts a leg, and lengthens it. In such cases, the other leg is adducted and is shortened and FLLI becomes serious as a result[6)]. Thus, FLLI can be reduced by adjusting the pelvis. In adjusting the pelvis, heel lift is used to adjust the pelvis[6)] or manipulation is applied to the sacroiliac joint[7)]. This study investigated a practical method for resolving the disequilibrium between both legs. FLLI was reduced through posterior-inferior ilium adjustment and its influence on foot pressure was analyzed.

SUBJECTS AND METHODS

The subjects of this study were undergraduates of University D located in Daegu Korea, and the study took place over 4 weeks in March 2008. Subjects were in good mental and physical health, but had LLI of at least 10 mm. Subjects who had FLLI due to surgery for leg trauma, or had degenerative osteoarthritis or rheumatic diseases were excluded from the study. Subjects were given an oral explanation about the study, and consented to the plan of their own free will. Subjects, who had FLLI, were randomly assigned to an experimental group or a control group. Pelvic adjustment was applied to the experimental group. Each group was composed of 10 males and 10 females, 20 subjects in all. Statistically, inter-group differences were not observed in sex ratio, age, stature and weight ($p>0.05$)

Pelvic adjustment was performed 3 times a week for 4 weeks, 12 times in all. Every time pelvic adjustment was performed, subjects received 3 or 4 rounds of manipulation. Measurement was performed before the intervention, and at 2 weeks and 4 weeks after the intervention was started. For the intervention, Gonstead's high-velocity low-amplitude prone position PI ilium push adjustment was applied for

pelvic adjustment. Subjects underwent the intervention in the prone position. The therapist adjusted the pelvis, putting a hand beneath the posterior-superior iliac spine (PSIS) to be adjusted and the other hand on the ischial spine of the opposite hip bone[8]. Pelvic adjustment was performed by a physical therapist who had 10 years' experience. Pelvic adjustment was performed using the therapist's body weight and acceleration of gravity. Subjects underwent the intervention wearing only their underwear so that clothes would not interfere with the manipulation.

An insole sensor, F-Scan (Tekscan Inc., USA), was used to measure foot pressure. Subjects walked for about 10 minutes, wearing low shoes in which manometers were placed, in order to fit them to their feet. After the zero point was adjusted, subjects walked 12 steps at walking pace. Foot pressure was measured from the 3rd step to the 10th step, using 'F-Scan Research TAM/STEM' (ver. 6.0; Tekscan Inc., USA). The maximum values of the 1st MPD (Metatarsal Pressure Difference) and HPD (Heel Pressure Difference) from foot pressure were measured. Each subject lay supine on a bed, and the length from the anterior-superior iliac spine (ASIS) to the medial malleolus was measured using a tape measure (TMM)[9]. Measurement was performed by 3 physical therapists who had at least 3 years' experience, and the mean value was calculated Beattie et al.[10] reported that LLI, measured by a tape measure, is not significantly different from that of radiological findings. The reason why the length was measured from ASIS was to include pelvic inclination, pelvic asymmetry and other physical parameters.

SPSS (Statistical Package for Social Sciences, ver. 12.0) was used to analyze the data. Also, two-way repeated ANOVA (Analysis of Variance) was used to ascertain the changes of intra-group and inter-group FLLI and foot pressure difference according to the time when measurement was performed. In addition, one-way ANOVA was used to ascertain the significance of the differences in both groups according to the time of measurement. Values of $p<0.05$ were considered statistically significant.

RESULTS

The FLLI of the experimental group was significant before the intervention, but the inequality was significantly reduced after the 2 weeks of intervention, and was remarkably reduced after 4 weeks of intervention. We found that FLLI was reduced in inverse proportion to the period of intervention. The HPD of the experimental group was significant before the intervention, but the difference was reduced after the 4 weeks of intervention(Table 1). Significant differences were observed in the statistics of intra-group and inter-group effects ($p<0.05$) (Table 2). The 1st MPD of the experimental group was significant before the intervention, but the difference was barely observable after the intervention. In particular, inter-group MPD differences were barely observable after 4 weeks of intervention ($p<0.05$) (Table 1). After 4 weeks of intervention, a significant improvement was observed in the inter-group HPD difference ($p<0.05$) (Table 2). Correlations

Table 1. Inter-Group FLLI, HPD, 1st MPD Differences (FLLI unit: mm, HPD & 1st MPD unit: kPa)

Group		Before Intervention	After 2 Weeks	After 4 Weeks
Experimental Group	FLLI	12.05 ± 0.39	5.85 ± 0.29	3.00 ± 0.36
	HPD	4.00 ± 0.45	2.85 ± 0.35	1.65 ± 0.30
	1st MPD	4.05 ± 0.35	2.65 ± 0.33	1.60 ± 0.29
Control Group	FLLI	12.20 ± 0.43	11.70 ± 0.42	11.35 ± 0.47
	HPD	3.55 ± 0.33	2.95 ± 0.33	4.15 ± 0.28
	1st MPD	3.25 ± 0.38	3.25 ± 0.29	3.65 ± 0.46

Mean ± SD . FLLI: functional leg length inequality. HPD: heel pressure difference. 1st MPD: 1st metatarsal pressure difference.

Table 2. Intra-group and Inter-group Effects of FLLI, HPD, 1st MPD Differences

		Type III SS	Degree of Freedom	Mean Square
FLLI	Period*	510.46	2	255.23
	Group*	228.80	1	228.80
	Period · Group*	353.26	2	176.63
HPD	Period*	20.41	2	10.20
	Group	05.13	1	05.13
	Period · Group*	49.21	2	24.60
1st MPD	Period*	21.95	2	10.97
	Group	03.80	1	03.80
	Period · Group*	40.61	2	20.30

*$p<0.05$.

Table 3. Correlation between FLLI and Foot Pressure

	Change of HPD	Change of 1st MPD
Change of FLLI	0.72**	0.77**

**p<0.01.

were sought. The correlations between FLLI and HPD and between FLLI and the 1st MPD had coefficients of 0.72 and 0.77, respectively ($p<0.05$) (Table 3). Specifically as the short leg got longer, LLI was reduced and therefore HPD and the 1st MPD were reduced.

DISCUSSION

Winter and Pinto[11] reported that pelvic obliquity is caused by LLI. McCaw[12] explained pelvic deformity in relation to stress caused by LLI and the biomechanical definition of contusions, also LLI changes ground reaction force and stance phase[13], and causes gait asymmetry[14]. Hertzman et al.[15] ascertained the preferences of 672 patients who underwent orthotherapy or medical therapy, 4 weeks after they underwent such therapies. Patients who underwent orthotherapy expressed their intense satisfaction. Consequently, pelvic adjustment is expected to reduce LLI.

The Gonstetad method was developed by Clarence Selmer Gonstead (1898 ~ 1978), and it is effective for pelvic analysis and listing. A vector force is applied to the x-axis, the y-axis and the z-axis using shearing force and torsion force, and it is effective for recovery of the function of motion segments and for improvement of neuralgia[16]. In this study, LLI was significantly reduced after pelvic adjustment. Thus, it was found that pelvic adjustment is effective for reducing FLLI. Alcantara et al., who applied high-speed low-amplitude adjustment to patients with sacroiliac joint movement, reported that patients' pains were relieved and that patients were able to return to daily life and work.

In a future study, the number of samples needs to be increased to generalize the results. Also, it will be necessary to study the pelvic adjustment to establish whether the effect is transient or long-lasting. Likewise, it will also be necessary to study the muscle shortening that causes LLI. This study is expected to be useful for reducing FLLI, or be useful for those who have gait disequilibrium caused by foot pressure difference.

To sum up, pelvic adjustment reduced FLLI and foot pressure difference and also foot pressure difference was reduced in proportion to FLLI reduction. In conclusion, we consider that pelvic adjustment is suitable for reducing FLLI as well as foot pressure difference.

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