

Original Article

# Effects of Pelvic Adjustment on Female University Students' Gait Variables

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**Abstract.** [Purpose] The purpose of this study was to examine the effects of pelvic adjustment using Gonstead techniques on posture in female university students. [Subjects] In this study, 30 female university students were selected and divided into a pelvic adjustment group of 15 subjects as an experimental group and a stretching group of 15 subjects as a control group. [Methods] Step length difference (SLD), stance phase difference (STPD), swing phase difference (SWPD), single support difference (SSD), and step time difference (STD) were evaluated in the subjects using an OptoGait. [Results] Whereas the adjustment group showed statistically significant differences in SLD, STPD, SWPD, SSD, and STD, the stretching group did not show any statistically significant differences in any of the items. [Conclusion] Pelvic adjustment can be applied using Gonstead techniques as a method of reducing differences in normal gait variables between the left and right sides in adults.

**Key words:** Pelvic adjustment, Optogait, Gait analysis

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## INTRODUCTION

Gait refers to moving the body to targeted points using the legs as a complex and integrated activity with low energy consumption involving alternative and harmonious movements with normal tension of the antigravity muscles<sup>1)</sup>. During gait, the smaller the step length difference (SLD), stance phase difference (STPD), swing phase difference (SWPD), single support difference (SSD), and step time difference (STD) between the left and right feet are, the higher the stability of the gait will be. Securing the stability of gait is an important factor when it comes to preventing falls. A fall may not only cause fractures and brain damage but also reduce mobility and motility, thereby bringing about many restrictions on living activities and leading to a declined quality of life<sup>2)</sup>.

Improvements in muscle endurance and gait velocity have been reported after performance of lower extremity exercises, and recent studies have emphasized that strengthening of not only the lower extremity muscles but also the lumbar muscles would improve the functional stability of the body and consequently enhance balance and gait ability<sup>3)</sup>. The pelvis is a structure located between the hip joint and the lumbosacral region to which many muscles are attached to adjust the movements of the hip joint and the

lumbosacral region. Therefore, the position of the pelvis is the most important element determining the body's sagittal alignment and posture<sup>4)</sup>. The lumbosacral joint affects the lumbar vertebrae, and the position of the lumbar vertebrae above the lumbosacral joint is determined by the position of the lumbosacral joint. The angle of the lumbosacral joint may vary depending on the position of the pelvis. Dynamic problems of the musculoskeletal system can be said to arise from the lumbar vertebrae, depending on the position of the pelvis. Anteroposterior gradient movements of the pelvis may affect the stability of the vertebrae and the alignment of the body. Therefore, proper alignment of the pelvis is an important element in gait<sup>5)</sup>.

Many studies have been conducted on the stability and postures of the pelvis, which are important for gait. There have been some cases in which lumbo-pelvic stabilization and posture were improved through bridge exercises<sup>6)</sup>, and there have been others in which lumbo-pelvic stabilization and posture were improved through diverse mat exercises<sup>7)</sup>. However, these methods have drawbacks in that they require time, space, and active participation from the subjects. On the other hand, pelvic adjustment is a treatment method that does not require much time. Although many previous studies have examined the effects of pelvic adjustment on functional leg length inequality<sup>8)</sup>, balance<sup>9)</sup>, posture<sup>10)</sup>, and so on, no previous research has examined the extent of changes in gait brought about by one session of adjustment. Therefore, the aim of this study was to examine the immediate effects of one session of pelvic adjustment on the gait variables of female university students.

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## SUBJECTS AND METHODS

Thirty female university students were selected and randomly assigned to a pelvic adjustment group of 15 subjects as an experimental group and a stretching group of 15 subjects as a control group. Those who had problems with their muscular, skeletal, or nervous system; those who felt pain in their lumbar region or pelvis during daily living; those who had improper postures due to burns or postoperative scars; and those who could not walk normally were excluded from the study. All included patients understood the purpose of this study and provided written informed consent prior to their participation in accordance with the ethical standards of the Declaration of Helsinki.

The adjustment group that participated in this study had a mean age of  $21.5 \pm 4.9$  years, a mean height of  $163.0 \pm 7.3$  cm, and a mean weight of  $54.1 \pm 7.1$  kg; the stretching group had a mean age of  $20.2 \pm 4.3$  years, a mean height of  $163.4 \pm 6.6$  cm, and a mean weight of  $57.1 \pm 9.5$  kg. Chi-squared tests were used to analyze the groups with regard to sex, and independent t-tests were used to analyze the groups with regard to age, height, and weight. The analyses showed no statistically significant difference ( $p > 0.05$ ), indicating that there was no problem in the homogeneity between the two groups.

In this study, the pelvic adjustment applied to the pelvic adjustment group was the high-velocity, low-amplitude technique for prone positions among Gonstead's theories. The direction of adjustment was set up before correction through gait analysis and Gillet tests<sup>11</sup>. Each subject was instructed to take a prone position and the height of the pelvis of the subject was checked to provide anterior rotation impacts on the innominate bone if it was posterior rotation displaced and to provide posterior rotation impacts on the innominate bone if it was anterior rotation displaced. When giving the impacts, the therapist overlapped her two hands and placed them on the posterior-superior iliac spine or ischial spine of the subject to give the impacts using her body weight, gravity, and acceleration<sup>8</sup>). This adjustment was conducted 3–5 times by one physical therapist with at least 10 years of clinical experience. In the case of the stretching group, to relieve any imbalance in muscles that may result in the imbalance of the pelvis, the muscles around the pelvis—specifically the erector spinae muscle, the rectus abdominis, the iliac muscle, the psoas major muscle, the quadriceps femoris muscle, the leg adductor muscle, and the quadratus lumborum muscle—were stretched. During the stretching, the therapist helped the subjects so that each muscle could be extended a little further than the maximum extended posture, and each subject was instructed to maintain each maximum extended posture for 10–15 seconds. After each stretching posture, the subject slowly restored the initial posture, took a rest for five seconds, and stretched once again. Each stretching posture was carried out three times in total, and the time spent for each session of stretching was 15 minutes.

The OptoGait (Microgate Italy, Bolzano-Bozen, Italy), used to measure gait variables, is gait analysis equipment made up of an optical detection system having 96 LEDs that transmit information using infrared frequencies via a trans-

**Table 1.** Comparison of SLD, STPD, SWPD, SSD and STD between before and after intervention in each group (mean $\pm$ SD) (unit: SLD-cm, STPD, SWPD, SSD, STD-%)

Category	Group	Before intervention	After intervention
SLD	Adjustment group*	3.3 $\pm$ 1.6	0.7 $\pm$ 0.5
	Stretching group	3.7 $\pm$ 4.0	3.1 $\pm$ 2.3
STPD	Adjustment group*	2.4 $\pm$ 2.9	0.7 $\pm$ 0.6
	Stretching group	2.1 $\pm$ 1.6	2.4 $\pm$ 1.6
SWPD	Adjustment group*	2.9 $\pm$ 1.9	1.5 $\pm$ 1.4
	Stretching group	2.6 $\pm$ 1.8	3.1 $\pm$ 3.0
SSD	Adjustment group*	3.1 $\pm$ 2.3	1.2 $\pm$ 0.9
	Stretching group	2.7 $\pm$ 1.9	2.8 $\pm$ 2.2
STD	Adjustment group*	3.1 $\pm$ 2.1	1.6 $\pm$ 1.1
	Stretching group	3.2 $\pm$ 1.8	2.8 $\pm$ 2.0

\*  $p < 0.05$ . SLD, step length difference; STPD, stance phase difference; SWPD, swing phase difference; SSD, single support difference; STD, step time difference

mission bar and the same number of LEDs on the receiving bar on the opposite side. The transmission and receiving bars of the OptoGait are installed on the two sides of a treadmill, and the SLD, STPD, SWPD, SSD, and STD during gait are calculated based on communication between the two bars being blocked by the patient's movements. The lengths of time a subjects runs, jumps, performs a series of jump tests, makes contact with the floor, or remains in the air can be calculated accurately from data captured with 1,000 instances of transmission/receiving per second. The dedicated software analyzes these basic data measured in real time and converts them into a series of movements.

The measured data were analyzed using SPSS 12.0 KO (SPSS, Chicago, IL, USA), and the collected data are presented as means and standard deviations. The significance of differences between before and after the experiment in each group was tested using paired t-tests and the significance of differences between the two groups was tested using independent t-tests. The significance level  $\alpha$  was set to 0.05.

## RESULTS

The pre- and post-intervention measurement results in the adjustment group and the stretching group were compared. The results revealed that the adjustment group showed statistically significant differences in all items (SLD, STPD, SWPD, SSD, and STD;  $p < 0.05$ ), while the stretching group showed no statistically significant difference in any of the items ( $p > 0.05$ ) (Table 1).

The pre- and post-intervention measurement results and changes between before and after intervention in the adjustment group and the stretching group were compared with each other. The results revealed that the pre-intervention measurements showed no statistically significant differences in any of the items ( $p > 0.05$ ), while the post-intervention measurements showed statistically significant differences in all of the items, and the changes between the pre- and

**Table 2.** Comparison of SLD, STPD, SWPD, SSD, and STD between the adjustment group and stretching group (mean±SD) (unit: SLD-cm, STPD, SWPD, SSD, STD-%)

	Category	Adjustment group	Stretching group
Before intervention	SLD	3.3±1.6	3.7±4.0
	STPD	2.4±2.9	2.1±1.6
	SWPD	2.9±1.9	2.6±1.8
	SSD	3.1±2.3	2.7±1.9
	STD	3.1±2.1	3.2±1.8
After intervention	SLD*	0.7±0.5	3.1±2.3
	STPD*	0.7±0.6	2.4±1.6
	SWPD*	1.5±1.4	3.1±3.0
	SSD*	1.2±0.9	2.8±2.2
	STD*	1.6±1.1	2.8±2.0
Change between before and after intervention	SLD*	2.5±1.5	0.6±4.2
	STPD*	1.6±3.0	0.2±1.3
	SWPD*	1.3±2.4	0.5±2.5
	SSD*	1.9±2.7	0.2±1.7
	STD	1.4±2.5	0.4±2.7

\* p<0.05. SLD, step length difference; STPD, stance phase difference; SWPD, swing phase difference; SSD, single support difference; STD, step time difference

post-intervention measurements showed statistically significant differences in all of the items except for STD (p<0.05) (Table 2).

## DISCUSSION

Humans are exposed to gravity because they walk upright; this exposure easily leads to misalignment in the pelvis and the lower extremities, which affects posture, gait patterns, and balance. The pelvis supports the abdomen, connects the vertebrae to the lower extremities, transmits body weight from the vertebrae to the lower extremities while standing, and enables proper posture to be maintained in order to generate smooth movements of the upper extremities<sup>12</sup>. Studies have reported that proper posture can be maintained and the upper body and the lower body can be controlled during movement to enhance gait ability only when the pelvis is in the neutral position<sup>13</sup>. Differences in lower extremity lengths can be found in all clinical cases, and these differences cause imbalance in the joints, vertebrae, and pelvis and disturb normal biodynamic functions<sup>14</sup>.

A normal position and the stability of the pelvis are thus important for a balanced gait. Although many previous studies have analyzed the gait of hemiplegia<sup>15</sup> or cerebral palsy patients<sup>16</sup> after diverse interventions using three-dimensional gait analysis, no study has analyzed the gait of such patients after pelvic adjustment; moreover, no studies that analyzed the gait of healthy adults after pelvic adjustment could be found. Therefore, the aim of this study was to apply pelvic adjustment to healthy adults and see if immediate changes in gait would occur.

Accordingly, changes in gaits were analyzed after pelvic

adjustment was applied using Gonstead techniques. As a result, the SLD, STPD, SWPD, SSD, and STD between the left and right sides decreased, indicating that pelvic adjustment had immediate effects on balanced gait in the female university students. In particular, the pre-intervention difference in SLD, which was 3.3±1.6 in the adjustment group and 3.7±4.0 cm in the stretching group, resulted from the anterior and posterior rotation rates of the left and right innominate bones being different. The post-intervention SLD of the adjustment group decreased to 0.7±0.5 cm because the posteriorly rotated innominate bone was imposed with impact for anterior rotation and the anterior rotation pelvis was imposed with impact for posterior rotation through pelvic adjustment.

In previous papers related to pelvic adjustment, Gong et al. (2011) advised that functional leg length inequality was reduced through pelvic adjustment among Gonstead's techniques, and these changes in leg length inequality reduced differences in foot pressure<sup>8</sup>. Moreover, Park et al. (2012) reported that the balance of 20 elderly males was improved through pelvic adjustment using Gonstead techniques<sup>9</sup>, while Cho (2013) stated that pelvic adjustment improved posture in female university students<sup>10</sup>.

The results of previous studies indicating that pelvic adjustment using Gonstead techniques improved postures, reduced differences in leg lengths, enhanced balance, and reduced differences in foot pressure are similar to the results of this study, which indicated that pelvic adjustment applied with Gonstead techniques had immediate effects on balanced gait in the female university students.

The changes balanced gait in the female university students brought about by pelvic adjustment, as mentioned above, are considered to have occurred because the pelvis is an important structure that supports the vertebrae and transmits body weight to the lower extremities. Functional leg length inequality is considered to have been reduced through pelvic adjustment, and these changes in leg length inequality are considered to have induced proper postures, as well as affects on gait variables, so that balanced gaits were shown. Therefore, the author recommends utilizing pelvic adjustment in patients who require properly balanced gaits. However, how long pelvic adjustment will enable balanced gait to be maintained should be examined through follow-up studies.

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