Original Article

J. Phys. Ther. Sci.
27: 2469–2471, 2015

The effect of gait training with shoe inserts on the improvement of pain and gait in sacroiliac joint patients

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Abstract. [Purpose] The purpose of the current research was to identify how gait training with shoe inserts affects the pain and gait of sacroiliac joint dysfunction patients. [Subjects and Methods] Thirty subjects were randomly selected and assigned to be either the experimental group (gait training with shoe insert group) or control group. Each group consisted of 15 patients. Pain was measured by Visual Analogue Scale, and foot pressure in a standing position and during gait was measured with a Gateview AFA-50 system (Alpus, Seoul, Republic of Korea). A paired sample t-test was used to compare the pain and gait of the sacroiliac joint before and after the intervention. Correlation between pain and walking after gait training with shoe inserts was examined by Pearson test. The level of significance was set at $\alpha=0.05$. [Results] It was found that application of the intervention to the experimental group resulted in a significant decrease in sacroiliac joint pain. It was also found that there was a significant correlation between Visual Analogue Scale score and dynamic asymmetric index ($r= 0.796$) and that there was a negative correlation between Visual Analogue Scale score and forefoot/rear foot peak pressure ratio ($r=-0.728$). [Conclusion] The results of our analysis lead us to conclude that the intervention with shoe inserts had a significant influence on the pain and gait of sacroiliac joint patients.

Key words: Sacroiliac joint, Shoe inserts, Gait

(This article was submitted Mar. 23, 2015, and was accepted Apr. 24, 2015)

INTRODUCTION

The sacroiliac joint, or SI joint (SIJ) is considered one of the crucial sources of low back pain, and many patients with sacroiliac joint dysfunction (SIJD) suffer from an unbalanced muscle structure[1)]. In manual medicine, SIJD is a potential cause of low back pain, and the prevalence rate of SIJD is reportedly 13.8% to 47.9% in the general population[2)]. Stability is attained through the self-locking mechanisms of form closure and force closure: the former is a special structural characteristic, and the latter refers to compression of muscles and ligaments[3)].

The anterior side of the sacrum is larger than the posterior side. Thus, any movement of the innominate to the anterior of the sacrum would lead the ilium to rotate to the anterior of the sacrum and move backward and the SIJ to be fixed like a wedge between the joints, which would cause anterior dysfunction[4, 5)]. Such a decrease in the stability mechanism could bring about pain or dysfunction in weight shifting through the SIJ[6)].

Any dysfunction of the SIJ might have a serious influence on the function of vertebrae above the sacrum. Dontigny reported that 80% of patients with low back pain caused by the SIJD were found to have malalignment of the pelvis owing to unilateral pelvic anterior tilt[5)]. Pelvic anterior tilt could cause disability in the pattern of pelvic movement and pain or dysbasia as well. The tilt would increase when standing and during the stance phase of the gait cycle and, as a consequence, lead to flexion of the hip joint and extension of the knee joint. Equinovarus can be found at the ankle joint[7)].

The pelvis should be placed in a neutral position for a proper posture and balanced movement of the upper and lower body in activities of daily living. Therefore, sacroiliac joint exercise is required to improve ambulatory ability in patients with SIJD, since SIJD is closely related to leg length discrepancy[8)].

Identification of the mechanical effect of the pelvis and damage to anatomical structures would help us better understand low back pain (LBP)[9)]. Foot mechanical features are considered important, and foot orthotics are used as a form of treatment to modify the movement of abnormal lower extremities associated with LBP. Shoes or foot orthotics often cause LBP, but at the same time, they can be used as clinical intervention tools[9–12)]. In particular, a shoe's heel height is a crucial factor in treatment of LBP, and it has been reported that slightly raising the heels by wearing shoe inserts might provide positive therapeutic effects for LBP[13)].

Previous researches have reported that slightly raised heels enhance the muscle activity of the erector spinae and make it fire faster[10, 14)], since raised heels might influence the central nervous system in order to control increased lumbar flexion, which eventually increases lumbar lordosis[15)]. Likewise, shoe inserts might be used as a clinical intervention

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tool to treat low back pain[15].

However, not many clinical studies on the effect of using shoe inserts have been presented yet. In particular, the effect of shoe inserts on the change in pain and gait has not been investigated much. Thus, the current study attempted to identify how gait training with shoe inserts affects the pain and gait of sacroiliac joint pain patients.

SUBJECTS AND METHODS

Thirty subjects (7 males, 23 females) were randomly selected and assigned to their respective groups randomly. The 15-patient experimental group (gait training with shoe insert group) consisted of 3 malese and 12 females. The 15-patient control group consisted of 4 males and 11 females. The ages of the subjects were 45.40±11.65 (mean±SD) for the experimental group and 43.00±14.84 for the control group. Their heights were 159.40±6.59 cm and 158.33±5.96 cm, whereas their weights were 59.46±6.8 kg, 54.33±6.30 kg, respectively. Patients with chronic low back pain along with SIJ pain were selected as subjects. Their leg length discrepancies, measured from X-ray images, ranged from 3 to 25 mm, and those who had had a surgery within the past year were excluded. Before participating in this research, all subjects were given an explanation about the content and procedures of the experiment. The subjects voluntarily participated in this research and signed an informed consent form. This study was approved by the Institutional Ethics Committee of Namseoul University.

The Visual Analogue Scale (VAS) was used to assess each patient's degree of back pain. The VAS is a simple, highly sensitive method representing the pain of a patient. Based on a scale of 0–100 mm, each patient's VAS was recorded, with 0 mm indicating no pain and 100 mm indicating an extreme degree of pain. The test-retest reliability (r = 0.99) and inter-rater reliability (r = 1.00) for the VAS appear to be very high[16].

In this study, shoe inserts made of polypropylene material (Alpus, Seoul, Republic of Korea) were used. The software of a Gateview AFA-50 system (Alpus, Seoul, Republic of Korea) was employed to measure foot pressure in a standing position and during gait, whereas the Gaitview Pro 1.0 software was used to measure the forefoot/rear foot peak pressure ratio (F/R ratio), asymmetric index (AI), and the laterality of gait. For each subject, the distance from the heel to the tip of the second toe was measured. The Gaitview Pro 1.0 software automatically divided the rear foot and forefoot by bisecting the distance from the front to the rear of each foot.

The subjects were asked to stand still after taking a few steps on the foothold of the Gaitview system in order to measure the foot pressure in the standing position. The foot pressure during gait was measured as follows: the subjects were asked to take their shoes off, walk as they normally do, step on Gateway with a leg, take a turn after a few more steps, and step on Gateway with another leg[17]. For the purpose of obtaining a natural gait, each patient was allowed 5 practice sessions before measurement.

The F/R ratio was obtained by dividing the forefoot pressure ratio by the rear foot pressure ratio by applying Pmax F/R ratio (Fore foot/Rear foot peak pressure ratio), which has been conventionally used to analyze the distribution of foot pressure in neuropathy patients with diabetes and Parkinson patients.

The balance (or imbalance) between the right and left leg was identified by calculating the right-left AI, that is, the right foot pressure vs. the left foot pressure when standing and during gait.

All the measured data were processed by the program of IBM SPSS Statistics version 19.0. The K-S test was conducted in order to analyze the normal distribution of the measured data. A paired sample t-test was used to compare the pain and gait of the subjects before and after the intervention. Correlation between pain and walking after gait training with shoe inserts was measured by Pearson test. The level of significance was set at α=0.05.

Table 1. Intragroup changes in pain and walking before and after the intervention

	Variables	Before	After
		Mean±SD	Mean±SD
Experimental group	VAS**	7.13±1.35	3.46±1.45
	F/R ratio	1.21±0.34	1.32±0.21
	Static AI (Rt/Lt)	4.00±2.83	4.68±2.42
	Dynamic AI (Rt/Lt)	4.94±4.29	3.22±1.86
Control group	VAS	6.73±0.09	6.46±0.99
	F/R ratio	0.97±0.09	0.93±0.06
	Static AI (Rt/Lt)	3.87±3.15	3.61±3.15
	Dynamic AI (Rt/Lt)	8.63±6.66	6.72±7.29

SD: standard deviation; VAS: Visual Analogue Scale; F/R: forefoot/rear foot peak pressure; static AI (Rt/Lt): static asymmetric index (right/left); dynamic AI (Rt/Lt): dynamic asymmetric index (right/left); * $p<0.05$, ** $p<0.01$

RESULTS

It was found that application of the intervention to the experimental group produced a significant decrease in their sacroiliac joint pain ($p<0.01$), as illustrated in Table 1. The post-experiment analysis of correlation among a set of variables found that there was a positive correlation between the VAS and dynamic AI ($r=0.796$, $p<0.01$) and that there was a high negative correlation between the VAS and F/R ratio ($r=-0.728$, $p<0.01$), as shown in Table 2.

DISCUSSION

Pain in the SIJ often leads to changes in gait pattern. If suffering from pain on both sides, an individual might walk with slower speed and shorter strides, whereas pain on one side would cause slight forward flexion of the body toward the other side without pain in order to reduce pelvic movement[18].

The current study attempted to identify how experimental intervention through gait training would change the patients' gait patterns after correction of a functional leg length discrepancy with shoe inserts in chronic low back pain patients with pain in the SIJ.

Table 2. Correlation between pain and walking after walking training with shoe inserts

		F/R ratio	Static AI (Rt/Lt)	Dynamic AI (Rt/Lt)
VAS	r	-0.728**	-0.186	0.796**

r: correlation coefficient; VAS: Visual Analogue Scale; F/R: forefoot/rear foot peak pressure; static AI (Rt/Lt): static asymmetric index (right/left); dynamic AI (Rt/Lt): dynamic asymmetric index (right/left); * p<0.05, ** p<0.01

Leg length discrepancy was measured in an upright position. The heights of the right and left femoral heads on X-ray images was compared to obtain the leg length discrepancy. The average error for this measurement tool in previous studies was 0.6 mm, and the maximum error was no greater than 2 mm[4].

The height of the shoe inserts that the experimental group wore was determined depending on the leg length discrepancy measured from X-ray images; most of them were 3 to 9 mm, and some subjects wore more than one insert if the discrepancy was greater than 10 mm[19]. The types of shoe inserts include insoles for foot correction in children and adolescents, insoles for diabetic foot care, and insoles for patients with musculoskeletal pain and for sports injury prevention, as well as insoles made of a variety of materials. In this study, shoe inserts made of a polypropylene material were used (Alpus, Seoul, Republic of Korea).

An advantage of the foot scan is that it is rather simple to perform and can determine various kinds of measurements: it measures plantar pressure and analyzes gait through pressure sensors. The current study utilized a Gaitview AFA-50 pressure sensor system to identify the characteristics of the gait patterns of chronic low back patients with SIJ pain by measuring and analyzing the laterality of plantar pressure and gait.

A significant decrease in SIJ pain was recognized after the intervention in the experimental group ($p<0.01$). Wolf[20] reported that shoe inserts may also contribute to a more stable pelvis in patients with an abnormal alignment because they reduce mechanical stress. It is possible that the decrease in pain found in the current study was also attributable to compensation by shoe inserts for a functional leg length discrepancy, consequently enabling the patients to walk with reduced mechanical stress on the SIJ.

The post-intervention analysis of the correlation between variables found that there was a significant correlation between the VAS and dynamic AI ($r=0.796$, $p<0.01$), which perhaps indicates that the difference between the left and right foot pressures owing to the SIJ pain decreased thanks to the intervention and consequently decreased pain.

A high negative correlation between the VAS and F/R ratio was found in this study ($r= -0.728$, $p <0.01$). This is consistent with previous studies that the more a function of the spine better F/R ratio is high tend to appear and the pressure is concentrated in the front portion of the foot during walking than patients with compromised function of the spine[21]. In the present study, gait training with shoe inserts decreased the SIJ pain significantly, improved the function of the spine, and concentrated the weight at the front part of the foot during gait, which is suggested to increase propulsion.

In conclusion, the present research found scientific evidence indicating that gait training with shoe inserts would be greatly helpful for the pain and gait of SIJ pain patients. Such gait training with shoe inserts would contribute to stabilization of the pelvis and spine, which is crucial for a comfortable and adequate gait. The results of the current study shed light on the importance of gait with shoe inserts in SIJ pain patients.

ACKNOWLEDGEMENT

Funding for this paper was provided by Namseoul University.

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