

The effects of lumbar stabilization exercises on foot pressure of older individuals while walking

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Abstract. [Purpose] The purpose of this study was to examine the effect of lumbar stabilization on pressure distribution in old women. [Subjects] The subjects of this study were 14 women aged 65 or older who agreed to participate in this study. They had a sufficient range of motion and muscle strength to perform the postures in this study's program and were without gait problems, congenital deformity, orthopedic disorder, or neurological disorder. [Methods] The participants performed a group exercise program that promotes lumbar stabilization for 50 minutes per session by following the instructions of a physical therapist. Gait Analyzer was used to measure the foot pressure of individual participants from three measurements for each lumbar stabilization exercise, and the mean values were used. The mean values were then compared between before and after the exercises by paired t-test. [Results] Pressure in F3 and F6 statistically significantly decreased from $2.06 \pm 1.23\%$ N/cm² to $1.55 \pm 1.02\%$ N/cm² and from $7.40 \pm 1.52\%$ N/cm² to $5.95 \pm 1.76\%$ N/cm², respectively, after the intervention, but no significant differences were found in the other foot areas. [Conclusion] The lumbar stabilization exercises affected the pressure evenly over the entire foot and, in particular, in the inner area of the forefoot.

Key words: Lumbar stabilization exercise, Foot pressure, Gait Analyzer

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INTRODUCTION

The Republic of Korea is an aging country. In 2011, the elderly Korean population accounted for 10.7% of the total population. In 2026, the Republic of Korea will be a super-aging country, with the elderly population predicted to make up 20.8% of the total population. Various types of dementia are expected to increase due to this increase in the elderly population¹⁾. Continuous growth in the older population may increase the number of dementia-related issues in public health, medicine, and welfare, which may then become serious social problems²⁾. Physical aging triggers a decrease in physical strength and functions. In particular, postural instability, degradation of physical balance ability, risk of falls, decline of muscle strength, and reduction of reflection ability may cause secondary problems³⁾. When elderly individuals exercise regularly, these problems may decrease, and the individuals may experience positive physical, mental, and social outcomes⁴⁾.

This study applied a group program of lumbar stabilization exercises to older subjects. Stability of the lumbar

spinal segments is very important biomechanically⁵⁾, and lumbar stabilization exercises based on the mechanism of sensory-motor control training in the lumbar region aims to improve biomechanical functions through stabilization exercises with lower than maximal intensity⁶⁾. Lumbar stabilization exercises help control an unstable posture painlessly and create good postures in the lumbar and pelvic areas by repeating contracting and relaxing movements while maintaining an isometric posture. This exercise activates and adjusts muscles such as the erector spinae muscle, quadratus lumborum muscle, multifidus muscle, rectus abdominis muscle, internal oblique abdominal muscle, external oblique abdominal muscle, and iliopsoas muscle, thus strengthening the lumbar region and improving balance ability⁷⁻⁹⁾.

Lumbar stabilization exercises enhance balance and physical functions. The exercises affect balance as well as the feet. The feet are the foundation for maintaining physical balance because changes in pressure on the feet may decrease physical balance and functions. Accordingly, the researchers in the present study applied lumbar stabilization exercises to older individuals and examined how the exercises affected the pressure distribution in their feet.

SUBJECTS AND METHODS

The study participants were 14 women aged 65 or older who used a community welfare center located in Gimhae,

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Republic of Korea. Ethical approval for this study was obtained from the Gimhae Senior Total Welfare Center. The subjects voluntarily consented to participate in this study. They performed lumbar stabilization exercises from October 15 to December 18, 2012. The selection criteria for the study were as follows: the participants had no gait problems, had a sufficient range of motion and muscle strength to perform the postures required in the study's exercise program, and did not have a congenital deformity, orthopedic disorder, or neurological disorder. The participants' average age was 74.00 ± 2.99 years, average height was 155.44 ± 4.46 cm, average weight was 57.89 ± 5.47 kg, and average foot size was 238.46 ± 2.47 mm.

The participants performed the group exercise program 50 minutes per session, twice a week, for 10 weeks. They performed the exercises by following the researchers' motions. First, as a warm-up exercise, they walked and stretched for 10 minutes. As the main program, they performed eight exercises. For the first exercise, in the supine position, they pulled one knee toward the thorax, and then maintained the posture. For the second exercise, in the supine position, they pulled both knees toward the thorax, and then maintained the posture. For the third exercise, in the supine position, they raised one leg, stretched the other leg and raised it, and then maintained the posture (alternating legs). For the fourth exercise, in the supine position, they raised both legs, made a bridge posture, and then maintained the posture. For the fifth exercise, in the side lying position, they stretched one leg, raised it, and then maintained the posture (alternating legs). For the sixth exercise, in the quadruped position, they stretched an arm, raised it, and then maintained the posture. For the seventh exercise, in the quadruped position, they stretched the knees, raised one leg posteriorly, and maintained the posture. For the eighth exercise, in the quadruped position, they stretched one arm and the opposite leg, raised them, and then maintained the posture (alternating sides). They performed these exercises for a total of 30 minutes. Then as a cool-down exercise, they walked and stretched for 10 minutes.

Gait Analyzer (TechStorm Co., Ltd., Daejeon, Republic of Korea) was used to measure the foot plantar pressure of the individual participants. The Gait Analyzer system can analyze foot pressure by region while the participants walk on a $384 \times 1,152$ mm plate. The sensor is a film-type pressure sensor consisting of a 2,304-cell matrix array. The plantar area is divided into 10 regions. Data on pressure distribution during walking were analyzed using the Gait Analyzer application software (ver. 3.1). Pressure data by region were collected from three measurements for each lumbar stabilization exercise, and the mean values were used^(10, 11). The measured data were analyzed with the SPSS 19.0 (SPSS, Chicago, IL, USA) statistical software. The average and standard deviation of the participants' general characteristics were also derived. A paired t-test was used to analyze the pre-test and post-test results. The statistical significance level was set at $\alpha=0.05$.

Table 1. Comparison of foot pressure distributions between before and after lumbar stabilization exercise (Unit: % N/cm²)

Region	Before	After
F1	0.29±0.35	0.30±0.29
F2	2.64±1.19	2.89±0.81
F3	2.06±1.23	1.55±1.02 *
F4	2.92±1.16	2.88±1.01
F5	8.49±1.79	8.07±1.85
F6	7.40±1.52	5.95±1.76 *
R3	5.23±2.79	5.71±1.85
R4	2.53±1.29	2.36±0.97
R1	2.39±1.68	2.60±2.11
R2	15.76±2.84	15.14±5.07

RESULTS

In Table 1, the pressure data for each region of the dominant foot are shown. There were no significant differences in the pressure distribution in F1, F2, F4, and F5 in the participants after the intervention (F1, the fourth and fifth toe areas in the forefoot area; F2, the second and third toe areas; F4, the outer area of the forefoot area; F5, the middle area of the forefoot area) ($p>0.05$).

In contrast, the pressure distributions in F3 and F6 decreased after the lumbar stabilization exercises (F3, the first toe area; F6, the inner area of the forefoot). The pressure in F3 and F6 statistically significantly decreased from $2.06 \pm 1.23\% \text{N/cm}^2$ to $1.55 \pm 1.02\% \text{N/cm}^2$ and from $7.40 \pm 1.52\% \text{N/cm}^2$ to $5.95 \pm 1.76\% \text{N/cm}^2$, respectively, after the intervention ($p<0.05$).

There were no significant differences in R3, R4, R2, and R1 in the participants before and after the intervention (R1, the outer area of the heel area; R2, the inner area of the heel area; R3, the outer area of the middle foot) ($p>0.05$).

DISCUSSION

Lumbar stabilization exercises affect the muscles and ligaments around the lumbar spine and correct them symmetrically, positively influencing stability of the spine and increasing the mobility and stability of the spine during movement. Among the muscles affecting the spine, in particular, the multifidus muscle is closely associated with spinal stability⁽¹²⁾, and the transversus abdominis muscle is related to lumbar spinal stabilization. The exercises in this study help stabilize the spine. The researcher selected a program that involved the multifidus muscle, the transversus abdominis muscle, and muscles around them. An exercise that contracted the transversus abdominis muscle by moving the arms and legs in the supine position, an exercise for the area around the abdominal region in a side lying position, and an exercise for lumbar spinal stability through contraction of the multifidus muscle and the transversus abdominis muscle in a quadruped position were performed^(6, 13–15).

Prior studies reported that the stability exercises used in this study had good effects. Sung¹⁶⁾ noted that spinal stabilization exercises performed by patients with chronic lumbar pain had positive effects and especially significantly decreased muscle fatigue. Kim¹⁷⁾ also observed that lumbar region stabilization exercises performed by patients with lumbar pain positively influenced the Oswestry disability index and lumbar mobility. In a study in which patients with chronic lumbar pain performed eight-direction tilt and rotation exercises, Gu¹⁸⁾ reported that the patients' pain and dynamic balance ability significantly improved. In a study in which 12 healthy adults performed lumbar stabilization exercises, Gray¹⁹⁾ reported that the activity of the patients' erector spinae muscle, rectus abdominis muscle, transversus abdominis muscle, and gluteus maximus muscle increased. As these study results show, lumbar stabilization exercises affect physical functions as well as the mobility and stability of the lumbar region. However, research on how this effect influences foot pressure has been lacking. Thus, we examined foot pressure. According to the present study results, the pressure distribution in the first toe area and the inner area in the forefoot decreased. The left and right symmetry and stability of the muscles around the lumbar spine increased. As a result, the tendency for foot pressure to be lopsided internally was reduced, and pressure was applied evenly to the entire foot. In addition, pressure on the second and third toe areas increased, although the increase was not statistically significant. Pressure on the inner area in the forefoot decreased, and pressure on the heel and outer areas of the feet increased; however, this change was not statistically significant. Pressure was distributed evenly over the entire foot. As previous studies have shown that lumbar stabilization exercises had a beneficial effect on balance, even distribution of pressure over the entire foot may have a beneficial effect on balance.

The limitations of this study are as follows. First, it was hard to identify individual differences among the participants during the participant selection process. Second, the number of participants was small. Therefore, further research should be performed with a qualitative experimental study in individuals with functional differences and a larger sample.

In conclusion, lumbar stabilization exercises apply pressure evenly to the feet. Therefore, performing these exercises before other exercises or activities can enhance older individuals' mobility and health.

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