

# The Effect of the Neurac Sling Exercise on Postural Balance Adjustment and Muscular Response Patterns in Chronic Low Back Pain Patients

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**Abstract.** [Purpose] This study aimed to examine the effects of the Neurac sling exercise on postural balance adjustment and muscular response patterns in chronic low back pain (CLBP) patients. [Subjects and Methods] Sixteen CLBP patients participated in this study. They were randomly and equally assigned to group I, whose members received ordinary physical therapy (40 minutes per time, four times per week), and group II, whose members performed a lumbar stabilization exercise using the Neurac sling after ordinary physical therapy (40 minutes per time, four times per week). The visual analogue scale (VAS) and Oswestry Disability Index (ODI) were used to evaluate exercise effects. BioRescue and electromyography were utilized for the measurement of changes in postural balance adjustment and muscular response patterns, respectively. [Results] Both groups saw their VAS and ODI decrease significantly. There were significant decreases in both groups in posturography as well, but group II recorded a greater decrease. There were significant increases in the flexion–relaxation ratio in both groups, and there were significant increases in the extension–flexion ratio in the left L1–2 of group I and in all elements of group II. [Conclusion] Lumbar stabilization exercise using the Neurac sling is effective in decreasing pain, improving damaged postural balance adjustment, and normalizing muscle response patterns of CLBP patients.

**Key words:** Chronic low back pain (CLBP), Neurac sling exercise, Postural balance adjustment

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## INTRODUCTION

Fifty to eighty percent of the population experiences low back pain, and this influences ordinary life and task performance<sup>1)</sup>. Ninety percent of low back pain patients recover within 6 weeks. When low back pain is sustained for more than 12 weeks, it is called chronic low back pain (CLBP)<sup>2)</sup>. Relative to people without pain, CLBP patients suffer from diverse problems with motor control, such as damage in postural adjustment<sup>3)</sup>, delay in muscular response<sup>4)</sup>, damage in perception capability during trunk movement<sup>5)</sup>, and increase in errors during postural recovery<sup>6)</sup>, that are related to low back pain.

Low back pain patients' motor control damage provides inaccurate proprioceptive input. In addition, loss of normal sensory information creates a strategy of postural adjustment for compensatory modification<sup>7)</sup>. In particular, proprioceptive input from the lower extremities and the trunk plays an important role in body stability and movement adjustment. Such proprioceptive disorders trigger restriction in range of motion (ROM) and postural balance adjustment together with chronic pain<sup>8)</sup>. In other words, damage in pos-

tural balance adjustment delays postural response patterns and response time<sup>9)</sup>. Danneels et al.<sup>10)</sup> observed that uncoordinated patterns of the multifidus muscle (a deep muscle of the lumbar spine) and the trunk muscles occurred, and Silfies et al.<sup>11)</sup> observed abnormal mobilization patterns in which mobilization of global muscles increased and activity of deep muscles decreased. These changes placed a load on and moved the spine, triggering recurrent low back pain.

A lumbar stability exercise using a sling has recently been applied to treat low back pain. Sling exercise enables proprioceptive exercise training on an unstable ground for recovery of neuromusculoskeletal damage and strengthens deep muscles that engage in stability, which is effective in normalizing muscle response patterns<sup>12)</sup>. In particular, the Neurac treatment method among sling exercises focuses on tonic stabilizers largely located near joints that play a crucial role in the mechanism of feed forward and is efficient in retraining motor units of muscles and reoperating inhibited actions through dynamic-static contraction of high intensity<sup>13)</sup>. Neurac treatment method utilizes passive fluctuations or mechanical vibrations, and Fontana et al.<sup>14)</sup> noted that when vibrations of low frequency were applied to the entire body, the proprioceptive sense of the lumbosacral area recovered. Muceli et al.<sup>15)</sup> observed that vibrations for a short time period were effective in increasing deep muscle

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strength and stabilization of chronic pain patients. In this study, we applied the Neurac lumbar stabilization sling exercise to CLBP patients and measured its effects on postural balance adjustment capabilities and muscle activity, thereby examining its effects on abnormal muscle response in lumbar pain patients.

**SUBJECTS AND METHODS**

*Subjects*

The subjects were 16 CLBP patients. The criteria for inclusion were as follows: pain existed for more than 12 weeks; experienced LBP defined as pain localized between lumbar level 2–4 and the inferior gluteal folds; patient had not undergone surgery of the lumbar area due to orthopedic problems; patient had visual analogue scale (VAS) and Oswestry Disability Index (ODI) scores of 6 or higher; patient did not have severe modification or fracture of the spine on X-ray; and patient had no sensory nervous system disorder, no vestibular system disorder, and no nervous or respiratory system disease. All subjects voluntarily consented to participate in this study. Data collection was started after approval was received from the University Institutional Review Board of Dongshin University. The characteristics of the subjects are provided in Table 1.

*Methods*

Using the method of picking a white or black ball, the subjects were equally assigned to group I, in which they received ordinary physical therapy, or group II, in which they performed the Neurac sling exercise. For ordinary physical exercise, a hot pack (20 minutes), ultrasonography (1.5 W/cm<sup>2</sup>, 5 minutes, Jireh Medical, Korea), and transcutaneous electric nerve stimulation (4 pps, 15 minutes, Hana-woo Medical, Korea) were applied to L1–2 and L4–5, 40 minutes per time, four times per week. Lumbar stabilization

exercise using the Neurac sling was conducted for 40 minutes per time, four times per week using the following four methods: First, a weight load exercise was performed under the Sling system. Second, passive fluctuation or mechanical vibration was selectively applied to body parts by using a stimulator (Redcord Stimula; Redcord). Third, the load was gradually increased. Fourth, treatment was adjusted so that pain was not triggered<sup>16)</sup>. Table 2 shows the specific method of exercise.

For postural adjustment ability, center of pressure (COP) was measured using BioRescue (RM Ingenierie Co., France). The COP elements of sway area, sway length, and sway speed were measured and analyzed. In order to measure static balance ability, the subjects stared straight ahead for 60 seconds on a foothold with their eyes open. In order to measure dynamic balance ability, the subjects rotated 180° on the foothold and stared straight ahead for 60 seconds<sup>17)</sup>.

Muscle activity was measured with electromyography (EMG) (Pocket EMG; BTS Co., Italy). Electrodes were attached to the right and left sides, 3 cm from L1–2 and L4–5. The frequency bandwidth was set at 20 to 500 Hz; the data, which were collected through filtering, were computer processed and the root mean square was calculated. For the

**Table 1.** Characteristics of study participants

Parameters	Group I (n=8)	Group II (n=8)
Age (years)	46.6 ± 19.7	48.6 ± 9.9
Sex (male/female)	4/4	3/5
Weight (kg)	61.3 ± 10.4	57.9 ± 4.9
Height (cm)	165.7 ± 4.0	164.6 ± 4.8
BMI (kg/m <sup>2</sup> )	22.3 ± 3.3	21.3 ± 0.8
Duration onset (months)	12.7 ± 3.0	18.7 ± 12.2

All data are expressed as means with SD

**Table 2.** Neurac sling lumbar stability exercise

Position	Exercise methods
Mobility exercise for back	Flex and extend the trunk while hanging the arms in the suspension unit and sitting on a sling bed.
Leaning forward	Get in a position on your knees, place the sling under your hands, contract deep muscles, and move the trunk forward.
Push-up plus	Get in a position on your knees, place the sling under both hands, contract deep muscles, and move the trunk forward while doing push-ups.
Supine bridge	Hang both legs on the suspension unit and raise the pelvis. Place the elastic suspension unit on the pelvis and then raise the pelvis.
Supine one leg bridge	Raise the pelvis while hanging only one leg on the suspension unit. Place the elastic suspension unit on the pelvis and then raise the pelvis?
Side-lying hip abduction 1	In a side-lying position, place the suspension unit on both legs and raise the pelvis. Place the elastic suspension unit on the pelvis and raise it.
Side-lying hip abduction 2	In a side-lying position, place the suspension unit on the top leg and raise the pelvis while keeping the bottom leg together with the top leg. Place the elastic suspension unit on the pelvis and raise it.
Prone bridge	In a prone position, place the suspension unit on the legs and raise the pelvis. Place the elastic suspension unit on the pelvis and raise it.

first 3 seconds, the subjects were in a standing position and flexed the lumbar vertebrae to the maximum ROM as if picking up an object; they then maintained a completely relaxed condition for 3 seconds and then extended the waist for 3 seconds in a neutral standing position. The flexion–relaxation ratio (FRR) was derived by dividing the 1 second maximum RMS (mV) during flexion by the 1 second maximum RMS (mV) during flexion–relaxation. The extension–flexion ratio (EFR) was calculated by dividing the 1 second maximum RMS (mV) during extension by the 1 second maximum RMS (mV) during flexion<sup>18</sup>. During clinical evaluation, subjective pain was evaluated using a VAS, and functional performance ability was evaluated using ODI.

Statistical analysis was performed with SPSS 12.0 for Windows. The normality test result did not show a normal distribution, and therefore nonparametric statistics were used. We used the Wilcoxon test for intra-group analysis and the Mann–Whitney U test for between-group analysis prior to and after the exercise. A statistical significance level was set at  $\alpha=0.05$ .

## RESULTS

Clinical evaluation prior to and after the Neurac sling exercise showed that the VAS and ODI scores significantly decreased in both groups after the exercise ( $p<0.001$ ) and that the VAS score differed significantly between the two groups ( $p<0.05$ ) (Table 3). The analysis of postural adjustment capabilities indicated that both groups saw sway area, sway speed, and sway length significantly decrease in static balance after the exercise ( $p<0.01$ ). For dynamic balance, there were significant decreases in all items except for sway area in group I ( $p<0.01$ ). There were significant differences

between the two groups for sway area and sway length of static and dynamic balance ( $p<0.01$ ) (Table 4). Analysis of differences in muscle response patterns showed that the FRR significantly increased in L1–2 and L4–5 in both groups ( $p<0.001$ ). Comparative analysis showed significant differences in the right and left L1–2 and in the right L4–5 between the two groups ( $p<0.05$ ). For the EFR, there were significant increases in all items except for the right L1–2 and right and left L4–5 ( $p<0.05$ ). Comparative analysis showed significant differences between the two groups in the right and left L1–2 and the right L4–5 ( $p<0.05$ ) (Table 5).

## DISCUSSION

Low back pain patients experience pain, decreased endurance, reduced flexibility, and restricted ROM of the lumbar joint<sup>19</sup>. In addition, damaged sensory receptors and changed muscular adjustment patterns trigger instability in postural balance and limited trunk movement adjustment<sup>8</sup>. For the recovery of balance ability, damaged proprioceptive senses of the lower extremities and the trunk should be improved, and muscle strengthening exercises for the entire lumbo-pelvic-hip complex should be conducted<sup>20</sup>.

Lumbar stabilization exercise using the Neurac sling resolves this problem and provides unstable ground, enabling sensorimotor training, and may simultaneously strengthen muscles that engage in stability<sup>16</sup>.

In this study, we examined the effects of ordinary physical therapy and lumbar stabilization exercise using the Neurac sling on CLBP patients by measuring VAS, ODI, posturography, and surface EMG. There were significant differences in VAS and ODI scores in the two groups after the exercise. This result suggests that ordinary physi-

**Table 3.** Changes in VAS and ODI scores between Group I and Group II (mean  $\pm$  SD)

Parameters	Group I		Group II	
	Pre	Post	Pre	Post
VAS	6.9 $\pm$ 0.7	3.3 $\pm$ 1.1***	7.0 $\pm$ 0.8	2.3 $\pm$ 1.3***#
ODI	20.0 $\pm$ 4.0	7.4 $\pm$ 2.1***	20.4 $\pm$ 3.9	6.0 $\pm$ 2.4***

The Wilcoxon test was conducted to compare differences between before and after exercise in each group (\*\*\* $p<0.001$ ). The Mann-Whitney U test was performed to compare differences between the two groups (#  $p<0.05$ ).

**Table 4.** Changes in balance between Group I and Group II (mean  $\pm$  SD)

Parameters		Group I		Group II	
		Pre	Post	Pre	Post
Static balance	SA (mm <sup>2</sup> )	29.2 $\pm$ 7.3	12.5 $\pm$ 2.7**	28.8 $\pm$ 10.3	14.5 $\pm$ 3.3***#
	SL (cm)	15.0 $\pm$ 2.1	10.8 $\pm$ 1.2**	15.9 $\pm$ 2.1	8.71 $\pm$ 1.9***#
	SS (cm/s)	0.2 $\pm$ 0.1	0.2 $\pm$ 0.1***	0.22 $\pm$ 0.1	0.17 $\pm$ 0.1**
Dynamic balance	SA (mm <sup>2</sup> )	31.0 $\pm$ 8.7	21.9 $\pm$ 3.1	33.2 $\pm$ 9.3	36.1 $\pm$ 6.8***##
	SL (cm)	24.8 $\pm$ 4.1	16.0 $\pm$ 2.3***	23.0 $\pm$ 2.6	11.0 $\pm$ 1.9***##
	SS (cm/s)	0.3 $\pm$ 0.1	0.3 $\pm$ 0.1**	0.4 $\pm$ 0.1	0.2 $\pm$ 0.1***

The Wilcoxon test was conducted to compare differences between before and after exercise in each group (\*\* $p<0.01$ ; \*\*\* $p<0.001$ ). The Mann-Whitney U test was performed to compare differences between the two groups (## $p<0.05$ ; ### $p<0.01$ ).

SA, sway area; SL, sway length; SS, sway speed

**Table 5.** Changes in muscle response between Group I and Group II (mean  $\pm$  SD)

Parameters		Group I		Group II		
		Pre	Post	Pre	Post	
FRR (ratio)	L1–2	Rt	2.1 $\pm$ 0.7	3.4 $\pm$ 2.1***	2.5 $\pm$ 2.3	4.5 $\pm$ 2.3***##
		Lt	1.7 $\pm$ 0.7	2.9 $\pm$ 2.6***	1.7 $\pm$ 1.8	3.6 $\pm$ 1.9***#
	L4–5	Rt	2.1 $\pm$ 1.7	3.1 $\pm$ 2.3***	2.5 $\pm$ 1.6	3.5 $\pm$ 2.1***##
		Lt	2.2 $\pm$ 2.0	3.5 $\pm$ 2.2***	2.6 $\pm$ 1.7	3.5 $\pm$ 2.2***
EFR (ratio)	L1–2	Rt	1.3 $\pm$ 0.2	1.5 $\pm$ 0.1	1.5 $\pm$ 0.2	2.0 $\pm$ 0.3***##
		Lt	1.4 $\pm$ 0.2	1.6 $\pm$ 0.2*	1.4 $\pm$ 0.2	2.0 $\pm$ 0.3***#
	L4–5	Rt	1.3 $\pm$ 0.2	1.4 $\pm$ 0.2	1.5 $\pm$ 0.3	1.8 $\pm$ 0.3***#
		Lt	1.4 $\pm$ 0.3	1.7 $\pm$ 0.3	1.4 $\pm$ 0.3	1.9 $\pm$ 0.3***

Wilcoxon test was conducted to compare differences between before and after exercise in each group (\* $p < 0.05$ ; \*\* $p < 0.01$ ; \*\*\* $p < 0.001$ ). The Mann-Whitney U test was performed to compare differences between the two groups (# $p < 0.05$ ; ## $p < 0.01$ ).

FRR, flexion–relaxation ratio, EFR, extension–flexion ratio

cal therapy and the Neurac sling exercise reduce pain and improve functional performance ability. In particular, the VAS score of group II had a significantly greater decrease compared with group I. We conclude that the sling exercise reduces load on the spine, reducing delivery of stimulation to ligaments and articular cavities, which are tissues sensitive to pain. We consider the sling exercise effective in reducing pain<sup>16)</sup>.

In order to look at changes in damaged postural balance adjustment ability in CLBP patients, the center of pressure was measured using posturography<sup>21)</sup>. We found significant decreases in sway area, sway length, and sway speed with regard to static balance ability in the two groups. However, with regard to dynamic balance ability, there were significant decreases in all elements in group I except for sway area. Decreases in sway area, sway length, and sway speed were greater in group II under dynamic conditions that required more balance recovery ability. This suggests that lumbar stabilization exercise using the Neurac sling reduces pain, enables proprioception–motor exercise and promotes activation of nerve roots<sup>16)</sup> and thus is effective in recovering damaged postural adjustment capabilities.

A method to measure trunk muscle activity of CLBP patients using surface EMG has been used but showed an abnormal FRP as a result of damage to muscle response patterns<sup>22)</sup>. This phenomenon is a disorder in which eccentric contraction of the erector spinae muscle decreases during flexion of the trunk, the muscle is not relaxed due to pain during complete flexion, there is some muscle contraction, and concentric contraction decreases during extension. It has previously been quantified by analysis with the FRR and EFR<sup>18)</sup>. In our study, both groups showed significant differences in FRR. In terms of the EFR, all items significantly increased only in group II. Given that the FRR in group I aimed at pain reduction increased, the erector spinae relaxed during complete flexion of the trunk as a result of a decrease in pain. In group II, pain was reduced and activity of concentric and eccentric contraction of the erector spinae was increased, increasing the FRR. A rehabilitation exercise program to activate nerve roots using a sling alleviates pain and activates global muscles and deep muscles, in-

creasing lumbar muscular strength. Shumway-Cook et al.<sup>23)</sup> observed that while conducting exercise on an unstable base of support, muscle activity exerted by muscles increased. When deep muscles are strengthened, anticipatory postural adjustment in which muscles maintaining stability respond in advance is activated, increasing stability in CLBP patient movement<sup>24)</sup>. Sling exercise using the Neurac treatment method promotes activation of nerve roots, smoothing coordination between the trunk and the hip joint and reducing abnormal flexion–relaxation phenomenon<sup>16)</sup>. When lumbar stabilization exercise using Neurac sling is used, it has a positive effect on muscle responses and on improving anticipatory postural adjustment ability.

Our study results showed that patients with recurrent CLBP had pain together with imbalance in postural balance adjustment and muscle response patterns and that these problems influenced their functions. Lumbar stabilization exercise using the Neurac sling is considered to reduce pain, improve damaged postural balance adjustment ability, and positively influence normalization of muscle response patterns.

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