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Original Article

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Effects of Sling Exercise on Pain, Trunk Strength, and Balance in Patients with Chronic Low Back Pain

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Purpose: The purpose of this study was to examine the effect of sling exercise on pain, trunk strength, and balance in patients with chronic low back pain in their 40s and 50s.
Methods: Twenty patients with chronic low back pain were divided into two groups, 10 patients in the exercise group using a sling and 10 patients in the waist stabilization exercise group, applying a random assignment, draw-out method, and sling exercise was applied for 50 minutes a day, 3 times a week, for a total of 5 weeks. For data analysis, a corresponding t-test was performed for within-group changes and an independent t-test was performed for inter-group changes, and the significance level was $\alpha = 0.05$.
Results: After 5 weeks, there were significant differences in all items of within-group changes, and the inter-group changes after 5 weeks demonstrated significant differences in pain, trunk flexion strength, and balance.
Conclusion: The results of this study showed that exercise using a sling had positive effects on pain, trunk flexion strength, and balance changes in chronic low back pain patients. It is suggested that sling exercise can be used as an intervention method for pain reduction and functional improvement of patients with chronic low back pain in clinical practice.

Keywords: Sling exercise, Chronic low back pain, Trunk strength, Balance

INTRODUCTION

Chronic low back pain is a very common symptom that occurs in more than 80% of the general population.[1] In addition, it is a non-specific mechanical pain that essentially occurs in the spine, intervertebral disc, or surrounding soft tissues,[2] and is a nociceptive pain caused by an overload of the vertebral joint following a functional instability of the back.[3]

Currently, the stability of the trunk is emphasized as a method of reducing chronic low back pain which is created by the cooperation of the abdominal, gluteal, pelvic girdle, paravertebral and other muscles, and it is essential for proper load and balance on the spine, pelvis, and kinetic chain.[4] And various exercise therapy approaches can improve back pain, physical function, muscle strength, and mental health.[5]

In various exercises therapy, trunk stabilization exercise is effective in reducing back pain and disability in adults and improving the quality of life,[6] and it can be effective in reducing pain and increasing the function of the trunk and can restore the trunk nerve root control of the lumbar spine and normalize the preceding posture control.[7-9] And it has a greater effect on daily activities by strengthening the abdominal muscles in the deep trunk and improving flexibility and balance ability than compound exercises such as stretching, resistance exercise, and fast walking.[10]

In various trunk stabilization exercise, the sling is a novel method of trunk stabilization exercise based on neuromuscular activation and is used to provide an unstable surface and close kinetic chain-based environment for motor control training.[11,12] It can be an effective method for activating multifidus and transversus abdominis muscles and stabilizing the lumbar region, reducing pain in patients with chronic low back pain and improving lumbar stability.[13,14]

Although there have been previous studies demonstrating that trunk stabilization exercise using a sling is effective for balance, most studies that applied sling exercise therapy in clinical practice were limited to patients with musculoskeletal system problems.[15] Although the causes and diag-

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noses of low back pain are diverse, there are few established treatments with strong evidence verifying their cost-effectiveness.[4] Therefore, this study aims to determine the effect of sling exercise for trunk stabilization on low back pain, muscle strength, and balance in patients with chronic low back pain.

METHOD

1. Subjects

Subjects of this study were diagnosed with chronic back pain by an orthopedic surgeon at K Hospital in 00 Metropolitan City, and 20 patients in their 40s and 50s and 10 women in their Numeric Rating Scale (NRS) scored 4-7 (Figure 1).[15] The study was conducted using a double-blind method.[16]

The subjects sample size was selected using the G*power3.1 (Heinrich Heine University Dusseldorf, Germany) program based on a previous study,[17] and the significance level ($\alpha = 0.05$), the effect size ($d = 1.6901018$), and the power ($1-\beta = 0.90$) were respectively set. As a result, a total of 18 individuals were selected, and two additional individuals were recruited in consideration of the dropout rate, for a total of 20 people. As for the classification method, 10 people in the exercise group using a sling and 10 people in the waist stabilization exercise group were randomly assigned the draw-out method. In the study, the subjects selected were individuals who had been diagnosed with low back pain for more than 3 months through physical examination and imaging, who had been informed of the purpose, research method, and effects of this study, and voluntarily expressed their intention to participate in the experiment by filling out a consent form.

The criteria for exclusion of subjects were as follows: 1) Those who exercise more than once a week within a month, 2) Those who have neurological symptoms such as radiating pain in the legs, 3) Those who have pain that interferes with movement.[11]

For the purpose of this study, all subjects provided written informed consent according to the ethical standards of the Declaration of Helsinki.

2. Experimental method

1) Experimental procedure

Prior to the experiment, the experimental group and the control group received superficial heat treatment for 20 minutes and deep heat treatment for 5 minutes on the area of pain.

The trunk stabilization exercise method of the experimental group consisted of bridge exercise using a sling, plank exercise using a sling, and side bridge exercise using a sling.

In the bridge exercise using a sling, in a supine position, place both

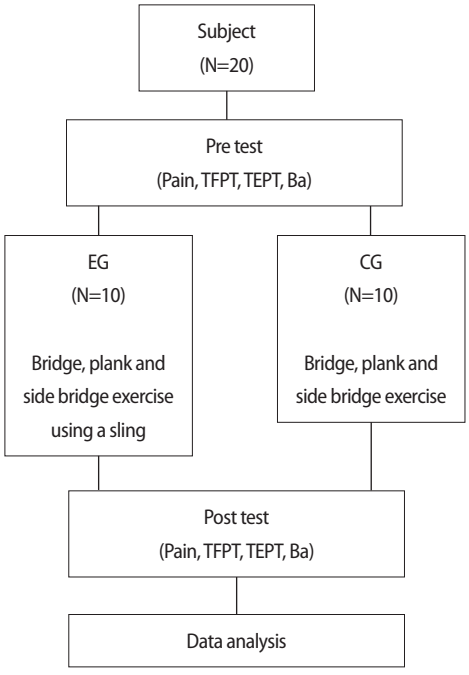

Figure 1. Study design. EG: experimental group, CG: control group, TFPT: trunk flexor peak torque, TEPT: trunk extensor peak torque, Ba: balance.

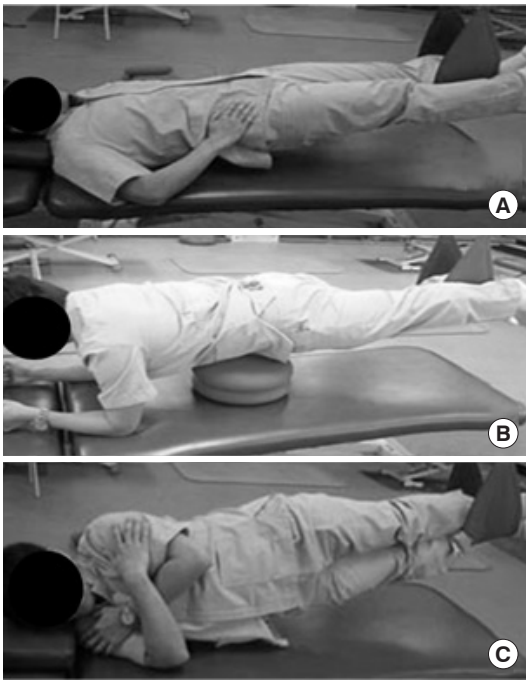

Figure 2. The trunk stabilization exercise method. (A) bridge exercise using a sling, (B) plank exercise using a sling, (C) side bridge exercise using a sling.

hands on the pelvis, put one ankle on the sling, and straighten the hip joint while keeping the left and right pelvis and ankle in the same position (Figure 2A).

In the plank exercise using a sling, in a prone position, with both elbow and shoulder joints bent at 90°, one hangs a single ankle on a sling on and lifts the opposite leg and pelvis to make the positions of both sides equal (Figure 2B).

The side bridge exercise using a sling is performed in a side-lying position with one shoulder resting on a support surface, placing hands on both shoulders and hanging one's ankles on the sling to keep the body in a straight line (Figure 2C).

The control group performed the bridge exercise, the side bridge exercise, and the plank exercise without applying the sling.

In the bridge exercise using a sling, one crosses one's hands on one's shoulders in a supine position and raising one's hips to the ceiling so that a straight line is formed from one's chest to one's knees.

In the plank exercise using a sling, in a prone position, with both elbow and shoulder joints bent at 90°, placing the center of gravity on the forearm instead of the arm, creating a straight line from head to toe.

The side bridge exercise using a sling is performed in a side-lying position with one shoulder resting on a support surface, placing hands on both shoulders and pressing one's heels and lifting one's buttocks without bending one's back to keep the body in a straight line.

2) Intervention Experimental procedure

The exercise program consisted of 5 minutes of stretching before and after exercise and 20 minutes of the main exercise for 20 minutes a day, 3 times a week, for a total of 5 weeks.

3. Measurements

1) Pain

A Numeric Rating Scale (NRS), ranging from the number 0 written on the left to 10 on the right, was used to determine the level of low back pain in a patient. The NRS is a 10-point scale measuring the severity of pain, in which 0 indicates no pain and 10 indicates extreme pain.[18]

2) Muscle strength

The muscle strength of the trunk flexor and trunk extensor was confirmed using a maximal isometric muscle strength measurement device (M3 Daignos, Schnell, Germany). The subjects sat on a chair and held both bars, and with the subject's thigh and pelvis fixed to the chair using Velcro, the subjects flexed the hip joint at 90° and the knee joint at 90°.[19]

The mechanical resistance device was applied to the front and low back at the 7th point of the thoracic vertebra to measure the maximal isometric strength of trunk flexion and extension.

The range of motion of the torso was set to 30° of trunk flexion and 20° of trunk extension before body communication based on the anatomical reference position of 0°, and the average value was used after measurements were taken a total of three times.

The unit used was a Newton meter (N·m) indicating the magnitude of the torque.

3) Balance

The balance was measured using a postural balance measurement system (Space Balance 3D, Cyber Medic, Co., Republic of Korea). The subjects stood upright on a stool, and balance was measured through the distribution of body weight. Weight movement was detected by a sensor on the front of the device.[20] And percentage was used as a unit to represent the static balance of the body.

4. Statistical analysis

The data collected in this study were processed using the SPSS 21.0 for Windows (SPSS Inc., Chicago, USA) program. The Shapiro-Wilk test was performed to confirm the normal distribution of the general characteristics of subjects, a paired t-test was used to verify changes within groups, and an independent t-test was used for changes between groups. The statistical significance level was set to 0.05.

RESULTS

1. General characteristics of subjects

A total of 20 subjects were enrolled in this study. The experimental group consisted of 10 individuals, including 5 males and 5 females, with an average age of 49.4 ± 5.8 years, an average weight of 69.1 ± 13.1 kg, and an average height of 165.1 ± 12.3 cm. The control group consisted of 10 individuals, 5 males and 5 females, with an average age of 49.9 ± 5.2 years, an average weight of 73.8 ± 15.0 kg, and an average height of 164.0 ± 12.4 cm. There was no significant difference between each group in terms of the general characteristics of the study subjects ($p > 0.05$)(Table 1).

2. Change in pain levels

Pain was significantly decreased in the experimental group and control

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Table 1. General characteristics of subjects (n=20)

	EG (n=10)	CG (n=10)	p
Gender (M/F)	4/6	4/6	
Age (yr)	49.4±5.8	49.9±5.2	0.773
Height (cm)	69.1±13.1	73.8±15.0	0.569
Weight (kg)	165.1±12.3	164.0±12.4	0.676

EG: experimental group, CG: control group, Values are presented as mean±standard deviation.

Table 2. Comparison of pre-post pain, muscle strength and balance between experimental and control

	EG	GG	t	p§
Pain (score)			2.635	0.017*
Pre	6.60±0.51	6.70±0.48		
Post	3.90±0.73	4.80±0.78		
Difference†	2.70±1.05	1.90±0.87		
t	8.06	6.862		
p‡	<0.001**	<0.001**		
TFPT (N·m)			2.439	0.025*
Pre	68.78±10.89	68.42±9.91		
Post	90.53±11.78	79.50±10.23		
Difference†	-21.75±6.46	-10.08±5.19		
t	-10.642	-6.134		
p‡	<0.001**	<0.001**		
TEPT (N·m)			1.186	0.251
Pre	29.64±7.74	29.78±7.15		
Post	49.14±10.80	42.54±13.89		
Difference†	-19.50±4.88	-12.75±7.36		
t	-12.624	-5.475		
p‡	<0.001**	<0.001**		
Ba (%)			3.088	0.006*
Pre	74.77±8.79	73.05±10.43		
Post	89.75±5.05	77.58±11.39		
Difference†	-14.98±8.09	-4.53±2.55		
t	-5.853	-5.61		
p‡	<0.001**	<0.001**		

Mean±standard, TFPT: trunk flexor peak torque, TEPT: trunk extensor peak torque, Ba: balance, EG: experimental group, CG: control group, †Difference: post-pre, ‡Paired t-test, §Independent t-test.
*p<0.05, **p<0.001.

group before and after 5weeks in the intragroup comparison ($p<0.05$), and there was a significant difference in the comparison between groups after 5 weeks ($p<0.05$)(Table 2).

3. Peak torque change in trunk flexion

The peak torque in the trunk flexion showed a significant increase in the experimental group and control group before and 5 weeks after the experiment in the intragroup comparison ($p<0.05$), and the inter-group comparison showed a significant difference after 5 weeks ($p<0.05$)(Table 2).

4. Peak torque change in trunk extension

The peak torque in trunk extension showed a significant increase in the experimental group and the control group before the experiment and after 5 weeks in the intragroup comparison ($p<0.05$), and there was no significant difference in the inter-group comparison ($p>0.05$)(Table 2).

5. Change in balance

Balance showed a significant improvement in the experimental group and the control group before and after 5 weeks when comparison was made within the group ($p<0.05$), and the inter-group comparison indicated a significant difference after 5 weeks ($p<0.05$)(Table 2).

DISCUSSION

Yue et al.[21] studied the effects of sling exercise on chronic low back pain and reported that sling exercise more effectively reduced low back pain and improved the functional state of the back compared to various exercises, thermomagnetic therapy, physical therapy, and drug therapy. And Ali et al.[2] studied trunk posture control and low back pain in 34 patients with low back pain and reported that 8 weeks of trunk stabilization exercise program intervention significantly reduced low back pain and disability. This was consistent with the findings of this study, in which low back pain was reduced through sling exercise over 5 weeks. It is thought to be an effective treatment method for relieving low back pain by strengthening the core muscles through sling exercise induces stability of the trunk.

This was consistent with this study, which found that low back pain was reduced through sling exercise over 5 weeks. It is thought that the sling exercise is effective in stabilizing the trunk and reducing low back pain.

This study showed a significant difference in pain levels between the experimental group and the control group before and 5 weeks after the experiment in the within-group comparison and showed a significant difference after 5 weeks in the inter-group comparison. This was consistent with the study of Yue et al.[21] and Ali et al.[2] in which low back pain and disability significantly decreased after 8 weeks of trunk stabilization exercise program intervention. It is thought that the sling exercise reduced the pain by controlling the movement of the trunk muscles and contributing to muscle strengthening and postural stabilization of patients with low back pain along with proprioception and neuromuscular control.

You et al.[22] studied the effect of 6-week sling exercise on trunk strength and endurance in 12 chronic low back pain patients. The sling exercise

improved the trunk strength of the left multifidus muscle and decreased the pain intensity of the patients with low back pain. And Ma et al.[23] studied the effect of sling exercise on trunk strength in 12 athletes and reported that sling exercise could more effectively improve the peak torque of the back and trunk flexor muscles compared to other existing exercise methods. This was consistent with this study, which found that the strength of the lumbar flexor muscle was increased through sling exercise over 5 weeks. It is thought that the sling exercise is effective in increasing core strength.

The peak torque changes in trunk flexion, this study found significant differences in the experimental group and control group before and after 5 weeks of intragroup comparison, and the inter-group results also showed a significant difference after 5 weeks. It is thought that the unstable kinetic chain-based environment using a sling contributed to postural stability along with an increase in the strength of the lumbar flexor muscles by improving the subject's trunk control and postural ability.

Morat et al.[24] studied the effects of various dynamic sling exercises on trunk muscle activation in 36 healthy adults and based on the results, reported that sling exercise was the most effective for activating abdominal muscles. And Cho and Park.[25] studied the effects of isometric trunk stabilization exercise using a sling on the trunk flexion-extension ratio and muscle strength in patients with chronic low back pain and neck pain. This was consistent with this study, which verified that 5 weeks of sling exercise resulted in a significant increase in the peak torque of the lumbar flexor muscles. It suggests that lumbar extensor stimulation and proprioception stimulation were both effective in strengthening lumbar extensor muscle strength and improving the trunk flexion-extension ratio in patients with chronic low back pain.

In this study, the peak torque was a significant difference in trunk extension between the experimental group and the control group before the experiment and 5 weeks after the experiment in the intragroup comparison, but there was no significant difference strength in the inter-group comparison. This is thought that the sling exercise affects the neuromuscular control of the core muscles and promotes the instability of the body, thereby affecting the increase in trunk stabilization.

Chen et al.[26] studied the effect of sling exercise on the balance ability of stroke patients. The results demonstrated that sling exercise could improve balance ability following a stroke. And Song et al.[16] studied the static and dynamic balance and physical activity of 12 children with spastic cerebral palsy after performing a trunk stability exercise program using a sling.

It has been reported that the sling exercise program can be used as an effective treatment for improving balance and physical activity in children with cerebral palsy who have difficulty walking.

This was consistent with this study, in which 5 weeks of sling exercise resulted in a significant difference in balance ability, which is thought to be because sling exercise affected the neuromuscular control of the erector and trunk stability.

The change of balance in this study showed a significant difference between the experimental group and the control group before and 5 weeks after the experiment in the within-group comparison, and the comparison between the groups showed a significant difference after 5 weeks. This is thought that the sling exercise on the unstable support surface affected the neuromuscular control, trunk control, and postural alignment of the patients with low back pain, thereby enhancing the balance ability.

As a limitation of this study, it is somewhat difficult to generalize to a specific small number of patients with chronic low back pain. Summarizing the results of this study, it can be concluded that chronic low back pain causes spinal instability, which causes abnormal movements. In the future, it is suggested that various studies on trunk instability will be helpful in the treatment of chronic low back pain patients in clinical practice.

The purpose of this study was to examine the effects of sling exercise for trunk stabilization on low back pain, trunk muscle strength, and balance in patients with chronic low back pain. The results verified that sling exercise had a positive effect on the pain, trunk flexion, trunk extensor, and balance ability of chronic low back pain patients. It is hoped that more studies will be conducted in the future to utilize active sling intervention for patients with chronic low back pain in clinical practice.

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