



Original Article

The effects of forced breathing exercise on the lumbar stabilization in chronic low back pain patients

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Abstract. [Purpose] This study was conducted to investigate the effects of forced breathing exercise on the trunk functions of chronic low back pain patients. [Subjects and Methods] Twenty-four patients with chronic low back pain were randomly divided into groups of respiratory effort and trunk stabilization exercises. The exercises were performed for 45 minutes, 3 times per week for 6 weeks. Spinal stabilization was measured as the compensation of the sagittal angle joint in relation to the lumbar external load. [Results] After the intervention, the forced breathing and stabilization exercise groups showed a significant difference in lumbar spine stabilization between the first and second stress tests and the control group also showed a significant difference after the intervention. The M1 and M2 tests of lumbar spine stabilization revealed no significant differences between the groups. [Conclusion] The results of this research demonstrate that forced breathing exercise therapy is effective at improving the trunk stability and daily living activities of chronic low back pain patients.

Key words: Forced breathing exercise, Low back pain, Stabilization exercise

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INTRODUCTION

The lability of lumbar segments following degenerative disc disease and decreased muscle control ability are important factors in lumbago. Accordingly, active trunk muscle stabilization exercises for the lability of lumbar segments are widely used in clinical practice¹⁻³⁾. Spinal stability is derived from simultaneous activities of the trunk muscles, and active simultaneous contractions are required to improve the spinal stability of lumbago patients with unstable lumbar segments^{4, 5)}. Reduced mobility of vertebral joints generates excessive stress or increased mobility of the joints; moreover, if the surrounding muscles cannot properly regulate this increased mobility, lability can occur⁶⁾. This epidemiological mechanism can manifest in various forms in all vertebral joints and can strongly influence functional changes of the spinal column. Lumbago patients who remain seated for long periods or have poor posture have a higher probability of kyphosis of the back joints and decreased flexibility⁷⁾; these lead to inefficient muscle tone of the spinal trunk and induce abnormal muscle compensation^{8, 9)}.

Among the trunk muscles, the respiratory muscles, internal oblique, abdominal muscles, back fibers, and spinal multifidus stabilize the spine. The pelvic floor muscles also influence spinal stability by cooperating with the trunk muscles to generate abdominal pressure^{10, 11)}. The transversus abdominis moves up and down while breathing and is the most important muscle required for blocking inspiration among the various muscles that contribute to spinal stabilization. Moreover, as the transversus abdominis is an expiratory muscle, it also increases abdominal pressure. Both muscles work by cooperating with the pelvic floor muscles. Thus, regarding the function of the trunk muscles, the simultaneous contraction and coordinated movement of the diaphragm, transversus abdominis, and pelvic floor muscle are the most important and basic elements of

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spinal stabilization and can be directly affected by forced breathing exercises. Furthermore, the movement of the spine joints, including the ribs, which are involved in the movement of the trunk joints, can also be affected through forced breathing exercises¹²).

In healthy adults, stable inspiration depends on the active contraction of the diaphragm and intercostal muscles. Stable expiration occurs as a passive process because of the elastic recoil caused by the relaxation of the inspiratory muscles. Forced respiration can be actively enhanced and accompanied by additional muscular contraction in the inspiratory and expiratory reserve volumes excluding one respiratory volume among vital capacity. Forced inspiration requires the mobilization of additional muscles such as the serratus posterior superior, serratus posterior inferior, latissimus dorsi, erector spinae, quadratus lumborum, pectoralis major, pectoralis minor, sternocleidomastoid, and primary inspiratory muscles to increase the speed and volume of the inhaled air. Forced expiration requires the active contraction of the four abdominal muscles (rectus abdominis, external oblique muscle, internal oblique muscle, transverse abdominis) to rapidly decrease the volume inside the thorax^{13, 14}). Sapsford reported that after simultaneous contraction of the pelvic floor and transversus abdominis, the lumbar lesion stabilizes during deep breathing¹⁵). The present study used a kinesiotherapeutic approach to determine the effects of forced breathing exercises, which regulate respiratory frequency and breathing capacity, on the spinal stabilization of lumbago patients during activities such as lifting heavy objects.

SUBJECTS AND METHODS

The subjects of this study were 24 adults living in Gwangju aged 20–40 years with intermittent chronic lumbago (<VAS 4) who did not have lumbar surgery experience, inflammatory spinal disease, spinal deformities, or neurologic radiating pain. The subjects were unable to perform muscular movements of the spinal trunk or cardiopulmonary exercise within one month of the study and did not receive any pathological diagnosis regarding the respiratory system. All subjects provided their informed consent to participation in this study. The subjects were randomly assigned the following two groups: the forced breathing exercise plus trunk stabilization exercise group and the trunk stabilization exercise group. The experimental period was 6 weeks, and a total of 18 exercise sessions were performed.

A SPIRO TIGER® (Idiag, Switzerland) was used for the forced breathing exercises. For respiratory muscle endurance training, the mouthpiece and respirator bag are connected by a pipe. There is a ventilation outlet between the pipe so that inflows and outflows of air pass through the vent during breathing. The tube handle is connected to the machine body by a cable. The main body has a mark and signal tone that gives visual and acoustic feedback for inhalation and exhalation, and can regulate and show the number of breaths per minute (65–10 times at maximum) and time (maximum, 99 minutes); it also prevents dizziness following forced respiration by regulating appropriate inflows and outflows of gas.

The trunk stabilization exercise started with deep contraction without external resistance and changed to isometric exercise through external resistance (i.e., at the end of the body or band). The change in dynamic movement as well as the position and direction of the lever were based on changes from the proximal to distal and vertical to horizontal directions as well as the motor developmental condition. The exercise followed basic principles, that changing the supporting surface from bodyweight ratio load to a weight-bearing position¹⁶). The first- and second-stage training contents were based on a 3-stage special exercise intervention for new motor skills acquisition involving decrease of the deep muscle control capacity of lumbago patients^{4, 17}). The first training stage was carried out by bending the knees while in the supine, lying sideways, prone, and crawling positions as well as sitting in a chair and standing on both feet. The neutral position of the spine was found through control of the pelvis without use of large muscles. The subjects were trained to perform the simultaneous contraction of the pelvic floor and transversus abdominis with diaphragmatic respiration. The contraction maintenance time was 10–60 seconds, and 5–10 sets were performed. The exercise times were 15 and 30 minutes for the experimental and control groups, respectively, and the intervention was conducted 6 times over 2 weeks. The weight support position of the subjects was trained by applying posture correction. The second-stage training involved bending the knees and pulling down elastic bands in a supine position, lifting the legs up while lying sideways, lifting dumbbells with both hands in a prone position, standing up from sitting on a chair, and squatting while lifting both arms in a standing position. The posture maintenance exercise was 10–30 seconds, each exercise was repeated 10–30 times per set, and 5–10 sets were performed. The exercise times for the experimental and control groups were 30 and 45 minutes per session respectively, and the exercises were performed 12 times over 4 weeks. During a total of 6 weeks of training, the break time between each set was one-half of the set exercise time, and the break time between exercises was 1 minute. The load test and a spinal mouse were used to measure vertebral joint stabilization. In the load test, the patients held a weight that was 3% of their body weight in both hands while standing comfortably with the shoulders flexed at 90° with their elbows spread. The first measurement was made by tracing the spine with a spinal analyzer. The same posture was maintained, and the second measurement was made by using the same method 15 seconds later. The measurement was performed by dragging the spinal analyzer across the spinous processes from the 7th cervical spine to the 3rd sacral vertebra. The stability of the vertebral joints was determined through two measurements of the thoracolumbar spine compensatory sagittal plane angle before and after exercise. Data analysis was performed using SPSS for Windows version 22.0 (SPSS Inc., Chicago, IL, USA). Differences between the groups were tested using one-way ANOVA, followed by the Student-Newman-Keuls multiple comparisons test when difference were detected. The statistical significance level was chosen as $\alpha=0.05$. This study was conducted after receiving approval regarding its safety, procedures, and ethics from the Research Ethics Committee of Dongshin University (BM-004-01).

Table 1. General characteristic of the subjects

	FBS group (n=12)	ST group (n=12)
Age (years)	28.8 ± 1.5	26.5 ± 1.6
Height (cm)	165.0 ± 2.2	163.1 ± 2.2
Weight (kg)	58.6 ± 3.2	56.0 ± 2.2
BMI (kg/m ²)	20.8 ± 0.8	20.7 ± 0.8

Mean ± SE. FBS: forced breathing and stabilization exercise group; ST: stabilization exercise group

Table 2. Comparison of the pre- and post-test lumbar stabilization results of each group (unit: °)

	Pre	Post
FBS group	-24.3 ± 2.2	-18.08 ± 2.3**
	-25.5 ± 2.3	-18.00 ± 2.3**
ST group	-26.7 ± 2.6	-24.50 ± 2.5**
	-29.3 ± 2.5	-23.33 ± 2.0**

Mean ± SE. FBS: forced breathing and stabilization exercise group; ST: stabilization exercise group. **p<0.01

Table 3. Comparison of the pre- and post-test thoracic stabilization results of each group (unit: °)

	Pre	Post
FBS group	37.1 ± 2.5	30.2 ± 2.2**
	38.8 ± 2.8	31.0 ± 2.6**
ST group	34.3 ± 1.1	34.5 ± 3.1
	37.2 ± 1.2	34.2 ± 2.1**

Mean ± SE. FBS: forced breathing and stabilization exercise group; ST: stabilization exercise group. **p<0.01

RESULTS

The general characteristics of the subjects are shown in Table 1. A total of 24 subjects participated in this study. Their average age, height, weight, and body mass index were 27.67 ± 1.09 years, 164.04 ± 1.52 cm, 57.29 ± 1.94 kg, and 20.75 ± 0.51, respectively. The average age, height, weight, and body mass index of the experimental group were 28.83 ± 1.53 years, 165.00 ± 2.17 cm, 58.58 ± 3.23 kg, and 20.83 ± 0.78, respectively; and those of the control group were 26.50 ± 1.55 years, 163.08 ± 2.19 cm, 56.00 ± 2.24 kg, and 20.67 ± 0.68, respectively (Table 1). There were no significant differences between the groups with respect to any of these parameters (Table 2). In the experimental group, a significant difference was found in lumbar spinal stabilization between the first and second stress tests, and a significant difference was also found after the intervention in the control group. No significant difference was found between the groups in the first measurement (M1) and second measurement (M2) tests of lumbar spinal stabilization. The intervention on dorsal spine stabilization in the experimental group, but it was not significant (Table 3).

DISCUSSION

Clinically, chronic lumbago patients usually make compensatory movements to maintain posture and the balance of the spinal trunk under an external load. These compensatory contractions affect not only the lumbar region, but also the cervical-shoulder and sternocostal areas. Clinically, early on, excessive muscle contraction usually persists in a location where there is joint lability. Subsequently thereafter, patients are unable to maintain a position for a long time and frequently adjust their support posture because of pain. Chronic lumbar pain patients with spinal lability eventually develop joint lability in many areas, which reduces movement through overall physical dysfunction. In turn, this decreases physical muscular endurance including activities of daily living and causes cardiopulmonary problems^{16, 18}. A state of local lability in the thoracolumbar spine is common in chronic lumbago patients. It can be explained by a state of decline and impairment in the neurological and epidemiological capacity of such patients. The stabilization of the trunk requires increased activity of the deep muscles that control various segments as well as motor control for harmonious muscle mobilization of the large muscles and joints that function in the sacral region^{19, 20}.

Enhancement of simultaneous contractile ability and muscular power can relieve pain and allow stable functioning in everyday life through abdominal pressure and trunk muscle strength improvements²¹⁻²³. The stabilization tests revealed there was a significant difference between the experimental and control groups as well as decreased lumbar extension angle at the initial examination after stress even in examinations performed after a considerable amount of time. Regarding the lability of the lumbar segments, the clinical signs of the extension pattern cause excessive contraction of the erector muscle increasing lordosis, impairing the mutual contractility of the spinal multifidus and transversus abdominis, and decreasing the respiratory function of the diaphragm. Regarding lumbar stabilization, the forced breathing exercises decreased the extension angle, eventually improved the breathing pattern, and stimulated the abdominal muscles. Therefore, the lumbar spine became more stable overall in the neutral zone due to hypertonic suppression of the spinal extensor muscles and decreased lordosis.

The findings of the lumbar spinal stabilization tests exhibit the same pattern as those of the lumbar spine. For functional and anatomic reasons, the forced breathing exercises stimulate the abdominal wall and stabilized the intrathoracic pressure. Also, the transverse abdominis muscle and external oblique, and erector spinae muscles played an important role in controlling vertebral shearing forces. Therefore, these exercises helped stabilize the dorsal spine in response to an external load^{24, 25}).

This study showed that forced breathing exercises performed by chronic lumbago patients decreased the thoracolumbar spine sagittal angle and contributed to functional improvement. These results demonstrate the effectiveness of forced breathing exercises as well as the necessity of spinal stabilization and functional enhancement for lumbago patients. These exercises are expected to help alleviate pain in lumbago patients through spinal stabilization. Therefore, the present exercises including forced breathing exercises are a possible kinesiotherapeutic approach for the functional improvement of the truncal spine of chronic lumbago patients.

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