

The effect of thoracic spine mobilization and stabilization exercise on the muscular strength and flexibility of the trunk of chronic low back pain patients

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Abstract. [Purpose] To investigate whether thoracic spine mobilization added to stabilization exercises increases the muscular strength and range of motion of the thoracic vertebrae of chronic low-back pain patients. [Subjects] This study enrolled 20 patients with chronic low back pain, who were divided into two groups. Ten subjects were randomly selected for the stabilization exercise group and the remaining 10 subjects received thoracic spine mobilization in addition to performing the stabilization exercises. [Methods] The patients performed stabilization exercises and received thoracic spine mobilization for 12 weeks. The range of motion and isometric muscular strength of the vertebrae of all subjects were measured before and after the intervention. [Results] In the comparison of muscular strength before and after the intervention, the change in muscular strength of the trunk flexors in the stabilization exercise group was 16.0 ± 7.4 Nm, and that of the thoracic spine mobilization group was 34.2 ± 7.6 Nm, a significant difference in each group. In the post-intervention intergroup comparison, the muscular strength of trunk flexors in the stabilization exercise group was 111.1 ± 16.9 Nm, while that of the thoracic spine mobilization group was 125.9 ± 11.3 Nm, a significant difference. Also, the muscular strength of the trunk extensors in the stabilization exercise group was 148.9 ± 31.8 Nm, while that of the thoracic spine mobilization group was 182.9 ± 37.2 Nm, a significant difference. The thoracic spine flexion in the stabilization exercise group was 29.8 ± 9 degrees, while that of the thoracic spine mobilization group was 38.7 ± 6.9 degrees, a significant difference. However, there was no significant difference in lumbar flexion values between the two groups. [Conclusion] Thoracic spine mobilization added to a stabilization exercise increased the muscular strength of patients with chronic low back pain.

Key words: Isometric muscle strength, Lumbar stabilization exercise, Thoracic spine mobilization exercise

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INTRODUCTION

Excessive pressure against the spine leads to a change in the intervertebral discs and to the phenomena of contraction, tension and rupture of the ligaments and muscles that support the vertebral body. The symptoms of low back pain develop in all ages, social strata, and occupations of all populations¹⁾. The duration of symptomatic manifestation of low back pain in most patients is approximately 2 to 3 months, and 80% to 90% of these patients generally experience recurrences²⁾. The causes of low back pain are various. However, soft tissue injury and weakening of the muscular strength of the trunk are primary causes of low back pain development³⁾.

These disorders lead to decreased endurance and limited range of motion of the lumbar vertebrae⁴⁾. Patients with low back pain may experience vertebral movement imbalance in flexion or extension of the trunk, and may also develop abnormal coupling motions, compared to normal individuals⁵⁾. The aim of lumbar stabilization exercise is to maximally reduce the stress biomechanically placed upon the vertebral infrastructure while a subject optimally performs required movements⁶⁾. Paris⁷⁾ defined “spinal instability” as having abnormal movements such as visually noticeable landing or catching during active movements, or a condition in which changes of the relative positions of the adjacent vertebrae are observable in a standing or prone position. Recently, the neutral zone theory, the logic behind “spinal instability,” was proposed by Pnaji et al⁸⁾. They asserted that the range of the neutral region would be affected by reciprocal reactions among the passive, active and neuronal control systems. Currently, lumbar stabilization exercise is recognized as an important therapeutic exercise due to “its effect on functional recovery and range of motion in patients with low back pain⁹⁾.” In human motion, the most flexible segments cause

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the largest angle of motion in a system consisting of multiple segments, and it has been observed that excessive movements of the lumbar spine are caused by limited motions of the thoracic vertebral segments. Maintaining a sitting position for a long time and aging increase thoracic kyphosis¹⁰. Furthermore, thoracic kyphosis-associated movement reduction in the thoracic vertebrae increases abnormal movements of the intervertebral bodies of the lumbar spine through a compensatory mechanism. Owing to the fact that such abnormal movements of the intervertebral bodies of the lumbar spine occur excessively, instability develops in facet joints of the vertebrae, finally inducing low back pain¹¹.

Spine manipulation therapy has largely been utilized to increase the spinal range of motion and reduce pain in patients with functional failure of the vertebral joints¹². Cleland¹³, suggested spine manipulation therapy as an appropriate treatment for patients with spinal pain. Recently, numerous studies of lumbar stabilization exercises have been reported. There are also reports of therapeutic manipulation and on the strength of lumbar vertebral extension. Studies of lumbar stabilization exercise include (1) "The effect of trunk stabilization exercise on posture adjustment" by Hyung-Soo Kim¹⁴); (2) "Cross-sectional comparative analysis of the multifidus muscle in compliance with the stabilization exercise approach," by Jung-Hoon Kim¹⁵); and (3) "The comparison of thoracic and lumbar stabilization between lumbar stabilization and thoracic spine mobilization exercise," by Jin-Gang Huh¹⁶). Jung-Ah Kim¹⁷) reported that thoracic spine mobilization was effective for functional improvement of lumbar spine stabilization when William's exercise and thoracic spine mobilization were implemented. Nevertheless, there have not been any studies of exercises that concurrently resolve both the difficulties of hypomobility of the thoracic spinal segments and hypermobility of the lumbar spine, which cause instability of the lumbar spine. In the present study manipulation of the spinal segments with hypomobility and stabilization exercises were performed for spinal hypermobility, and their effects on range of motion and muscular strength were examined in patients with chronic low back pain.

SUBJECTS AND METHODS

This study enrolled 20 patients with chronic low back pain, who were divided into two groups. Ten patients were randomly selected for the stabilization exercise group; and the remaining 10 patients received thoracic spine mobilization in addition to performing stabilization exercises. Flexion of the trunk, muscular strength of the trunk extensors, and flexibility of the thoracic and lumbar vertebrae were measured, and the subjects performed stabilization exercises and received thoracic spine mobilization 3 times a week for 12 weeks (Table 1).

The subjects understood the principle objective and method of this study and voluntarily provided their written informed consent before participating. The study protocol was approved by the institutional review boards of Daegu university of Daegu.

A Spinal Mouse was used to measure the range of motion of the spine. According to a study conducted by Seichert¹⁸),

Table 1. General characteristics of the subjects

	Lumbar stabilization (n=10)	Thoracic spine mobilization (n=10)
Age (years)	44.2±7.1	43.1±7.8
Height (cm)	165.3±8.3	166±9.0
Weight (kg)	63.4±11.7	62.9±10.7
Mean±SD		

the reliability coefficient of the Spinal Mouse is 0.96. In a comparative study of the lumbar shapes of the sagittal plane and mobility of normal individuals, utilizing a functional radiologic study and a Spinal Mouse, it was reported that these two methods did not show any differences and there was a high correlation between these two methods. The Spinal Mouse, an automatically-measuring device for spinal segmental motions, was dragged down from C7 to S3, sagittally, along the vertebral column of subjects in three postures of vertebral extension, flexion and lateral flexion. The data recorded of the spinal segments, was then transferred wirelessly to a computer. The measurements included the length of the spine, degree of scoliosis, and the angles of each segment of the thoracic and lumbar vertebrae. For the measurement of spinal segmental motion, the subjects were asked to adopt a neutral posture, which is the most comfortable position for the waist. While maintaining the neutral posture, the segmental motion of the spine was measured from C7 to S3. Next, segmental spine motion was measured in the same way, while the trunk was actively flexed to the maximum. The measurements were repeated three times and the mean value was calculated. A single examiner took measurements in order to minimize the margin of error of the test.

An isometric sthenometer (ISO-check, Germany) was used to measure the muscular strength of the lumbar deep muscles. The maximum and average muscular strengths were obtained by measuring isometric contraction. Subject sat on the device and the knees and chest were secured with straps. Then, lumbar flexion, extension, lateral flexion and rotation were measured. Lumbar flexion or extension was measured by pushing the lumbar region maximally in the direction of flexion or extension while holding the chest belt tightly. Lateral flexion was measured by pushing the fixed shoulder bar with maximum force, while rotation was measured by rotating the lumbar spine with maximum force while holding the fixed handle. The maximum muscular force was measured in each direction for six seconds, and the force is reported in Nm.

For the purpose of strengthening the transverse abdominis muscle, multifidus muscle, quadratus lumborum muscle, external oblique abdominal muscle, and internal oblique abdominal muscle, subjects performed active stabilization exercises for one hour daily, three times a week for twelve weeks. The stabilization exercises were divided into warming-up, main, and cool-down exercises. The warming-up exercise was walking on a treadmill for fifteen minutes. The cool-down exercise included three types of stretching exercise. The main exercise included 3 types of workouts in 1 set and 3 sets were performed. Sixty percent (60%) of the maximum muscular strength was used as the intensity

of the exercise. The exercises were repeated 15 times for one set and 3 sets were performed with 2-minute rest intervals between them. A slow exercise speed was used so that subjects did not experience pain. The cool-down exercises were comprised of stretching exercises for the rectus femoris muscle, the hamstring muscle, and the peroneal muscle group¹⁹). The main exercise of the stabilization workout program was performed with the aim of promoting the muscular strength of the quadriceps femoris muscle and the hamstring muscle. Before starting the exercises, subjects pulled-in their abdomens so that a ball on the back did not sink down core muscles were contracted. For Exercise (1), the subjects were asked not to push the medial aspect of the thighs, so that no force was put on a small ball placed between the knees, and then flexed and extended the knees slowly as if pushing against a wall.

Exercise (2): Subjects alternately raised their upper and lower extremities in a prone position. When raising the upper and lower extremities, the pelvis and the chest had to be in contact with the ground, with the lumbar spine not overly extended. This procedure was performed alternately on both the left and right sides.

Exercise (3): Subjects flexed their knees and placed their hands on the neck area in a supine position, then vertically raised their elbows up to the level of the scapula, lifting the upper body. Then, the upper body was slowly brought down while maintaining the core contraction.

Exercise (4): Subjects flexed their knees and elbows at 90 degrees while lying on a bench. Then, they rotated their arms while pushing their elbows back to the limit of movement of the shoulder joints and contracted the rhomboid muscle.

Exercise (5): Subjects stood with their legs shoulder-width apart in a walking position. Then, they lowered the pelvis by flexing the knees, and raised, the pelvis extending the knees. This exercise was performed with the leading leg alternated. This is an endurance exercise for the femoral and gluteal muscles, and is an effective workout that must be carried out in with the core muscles contracted.

Exercise (6): The subjects bent both knees to 90 degrees to a decubitus position. Then, the upper part of the lower extremities was raised so that they were horizontal. The subjects' legs were crossed (in an inversion state) and the pelvis was not allowed to move. Then the core muscles were contracted, This exercise was alternately performed on both the left and right sides. The aim of this exercise was to strengthen the endurance capacity of the gluteus medius, and the internal and external oblique abdominal muscles.

Exercise (7): A rubber tube (Theratube) was placed on the right ankle with the subjects in a prone position, and the anterior aspect of the thigh was positioned on the edge of the bench. Then, the flexed knee joints and hip joints were extended. slowly, with contraction of the core muscles, so that lumbar movement was minimized. This exercise was performed to strengthen the gluteus maximus and the erector muscles of the spine.

Exercise (8): This was an exercise of the upper extremities using a pulley. Subjects stood next to a pulley. Movements of the upper extremities were performed at angles of less than 90 degrees. The shoulder joints were externally and alternately rotated slowly.

Exercise (9): With both hands and feet are on the ground, subjects contracted the transversus abdominis muscle and then raised their knees, without lumbar lordosis, and with the neck and the spine aligned straight. Both the stabilization exercise group and mobilization group performed these exercise.

Thoracic mobilization therapy was performed for the thoracic spine mobilization group, thoracic mobilization therapy was performed for five minutes before starting the stabilization exercises. The thoracic mobilization therapy was the manipulation therapy reported by Kaltenborn²⁰). Traction was applied to the articulations of the thoracic spine with restricted movements. Both hands were crisscrossed so that each hand held the opposite shoulder of the subjects in a supine position. The subjects facing the therapist. While one hand of the therapist was placed on the thoracic segment with movement restriction, the other hand held and pushed the elbow of the subject. In a sufficiently relaxed state, a very short and fast force is applied downward toward the ground.

SPSS 12.0 version was used to analyze data collected in this study with a significance level of $p=0.05$. The ranges of motion of the spine and isometric muscular strengths of the stabilization exercise group and the thoracic spine mobilization group were tested for differences using the independent t-test for intergroup analysis, and the paired sample t-test for intragroup analysis.

RESULTS

In the comparisons of the results before and after exercises within each group the change in the muscular strength of the trunk flexors was 16.00 ± 7.38 Nm in the stabilization exercise group, while that of thoracic spine mobilization exercise was 34.2 ± 7.6 Nm significant differences in the groups. The change in the muscular strength of the trunk extensors in the stabilization exercise group was 17.5 ± 8.5 Nm, and that of the thoracic spine mobilization exercise group was 55.3 ± 18.3 Nm, significant differences in both groups.

The change in the flexibility of the thoracic flexor in the lumbar stabilization exercise group was 28.2 ± 7.7 degrees, and that of the thoracic mobilization exercise group was 32.6 ± 10.1 degrees, significant differences in both groups. The change in the flexibility of the lumbar flexor in the stabilization exercise group was 38.2 ± 16.6 degrees, while that of the thoracic spine mobilization exercise group was 45.4 ± 13.9 degrees significant differences in both groups.

In the intergroup comparisons, the muscular strength of the trunk flexors in the stabilization exercise group was 111.1 ± 16.9 Nm, and that of the thoracic spine mobilization exercise group was 125.9 ± 11.3 Nm, a significant difference. The muscular strength of the trunk extensors in the stabilization exercise group was 148.9 ± 31.8 Nm, and that of the thoracic spine mobilization exercise group was 182.9 ± 37.2 Nm, a significant difference.

The flexibility of the thoracic spine flexion in the stabilization exercise group was 29.8 ± 9 degrees, while that of the thoracic spine mobilization group was 38.7 ± 6.9 degrees, a significant difference. However lumbar flexion did not show a significant difference between the groups.

DISCUSSION

Kim²¹⁾, reported that there was a significant decrease in the kyphotic curvature of all thoracic segments in both sitting and standing postures in a group of patients with low back pain after 3 weeks exercise of the transversus abdominis muscle. White²²⁾ suggested ranges of flexion and extension for the thoracic and lumbar spine: 4 degrees for the upper part of the thoracic spine, 6 degrees for the middle spine, 12 degrees for the lower part of the thoracic spine, and 20 degrees in the lumbar segments. Jung-Ah Kim¹⁷⁾, based on comparisons of a thoracic spine mobilization group and a William's Back Exercise group, that the thoracic spine mobilization group showed a decrease in kyphosis and pain the thoracic spine as well as an increase in lumbar stability. Huh¹⁶⁾ prescribed exercises for a thoracic spine mobilization group and a lumbar stabilization group for 3 and 6 months, and reported that the subjects of the thoracic spine mobilization group showed a significant increase in their ability to raised both of their hands maximally above their heads. Kim²³⁾, reported that sling exercises for lumbar stabilization and muscular strength, increased subjects' muscular strength. Kim¹⁴⁾, reported the effect of trunk stabilization exercises for postural control for patients with chronic back pain. The muscular strengths of the transversus abdominis, rectus abdominis, and the external oblique abdominal muscle increased in the groups performing matt-and-ball exercise or sling exercise with isometric extension. They concluded that the muscular activation was effective and that the exercises that decreased the Oswestry Disability Index also increased muscular strength. This is because thoracic joint mobilization or self-stretching exercises for the spine improve limited movements of the spine, recover facet joint sliding, and normalize the articular capsule, thereby decreasing kyphosis and enhancing the flexibility of thoracic extension²⁴⁾. In the present study, stabilization exercises with thoracic spine mobilization were performed for 12 weeks resulting in a significant increases in the strengths of the trunk flexor, trunk extensor and thoracic flexor muscles, a finding which is in agreement with those of previous studies. Many exercise methods have been exhaustively researched in an effort to prevent the vicious cycle of spinal tissue injury inducing spinal instability, and to find clinically safe and effective exercise methods. From the aspects of safety and function of the lumbar spine, many researchers are agreed about the importance of muscular stabilization²⁵⁾. Moreover, Kaltenborn²⁶⁾ reported that the therapeutic method of controlling abnormal movements through relative adjustment of excessively restricted or large segmental movements could affect lumbar stability, and that lumbar stabilization could be improved by thoracic mobilization and thoracic manipulation for the improvement of thoracic mobility²⁷⁾.

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