

Effects of Spinal Stabilization Exercise on the Cross-sectional Areas of the Lumbar Multifidus and Psoas Major Muscles, Pain Intensity, and Lumbar Muscle Strength of Patients with Degenerative Disc Disease

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Abstract. [Purpose] The aim of this study was to evaluate the efficacy of using spinal stabilizing exercise to reduce atrophy of the multifidus and psoas major muscles, reduce the levels of pain and disability, and increase paraspinal muscle strength in patients with degenerative disc disease (DDD). [Subjects and Methods] In 33 patients (Age range: 25–65 years) diagnosed with DDD, spinal stabilization exercise was conducted for 8 weeks. The levels of pain and disability were measured before and after exercise using the visual analogue scale (VAS) and the Oswestry Disability Index (ODI). Paraspinal muscular strength in four directions was evaluated with a CENTAUR 3D Spatial Rotation Device. Cross-sectional areas (CSAs) of both the left and right multifidus and the psoas major at the upper endplate of L4 were measured before and after exercise using computed tomography (CT). [Results] After 8 weeks of spinal stabilization exercise, the pain and lumbar disability in subjects decreased significantly from 6.12 ± 1.24 to 2.43 ± 1.14 . The ODI score also improved from 20.18 ± 7.14 to 8.81 ± 5.73 . In addition, paraspinal muscle strength increased significantly, while the CSAs of the left and right multifidus and psoas major widened as compared with the pre-exercise size. [Conclusion] Spinal stabilization exercise was effective for reducing pain and disability in DDD patients. It was an effective adjunct to aid rehabilitation in these cases.

Key words: Degenerative disc disease, Spinal stabilization, Multifidus

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INTRODUCTION

Low back pain (LBP) is one of the most common diseases in modern society, occurring in nearly 80% of the population. There is a high potential for recurrence, so successful rehabilitation is important in preventing the return of LBP^{1, 2}). Though there are various causes of LBP, the primary factors for developing LBP are damage to the soft tissues of the trunk and weakening of the muscles, leading to pain, decreased muscle endurance and flexibility, and restriction of spine movement³).

In particular, it has been shown that the deep layer lumbar spine muscles of LBP patients experience more atrophy^{4–7}) when compared with healthy controls, and the contraction speed of their muscles is decreased. Such damage and muscle weakening give rise to disc degeneration and

cause pain and instability of the spine⁸). Another study reported that excessive mechanical load when applied to the spine destroyed spinal tissues, led to disc degeneration, and worse, caused irreversible alterations of cellular tissues^{9, 10}). Once disc degeneration had progressed, elimination of cartilage was quickly increased, the height of the disc was shortened, instability of the spine developed, and the deep intrinsic muscles underwent atrophy, taking on a major role in destabilizing the spine⁹).

Recent studies have shown that spinal stabilization exercise for acute, subacute, and chronic lower back pain (CLBP) patients produced a positive effect in terms of relieving pain, improving spinal function, and reducing limitations in daily life^{11, 12}). The basic concept was that these spinal stabilization exercise programs enhanced musculoskeletal capacity, which maintained the neutral posture of the spine by preventing excessive movement¹³). Some researchers have focused on activating the transversus abdominis, multifidus, and psoas major muscles through various exercise implements¹⁴) because strengthening these deep muscles helps in stabilizing the spine quickly¹³). Other researchers have insisted that in the first occurrence of LBP, atrophy of the multifidus occurred quickly; such a dysfunction of this

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Table 1. General characteristics of subjects

Gender	Age (years)	Duration of symptoms (month)	Height (cm)	Weight (kg)
14 male, 19 female	44.2 ± 11.6	19.5 ± 18.2	165.63 ± 7.8	63.03 ± 8.5

muscle in CLBP patients might be related to relapsed LBP, meaning that this muscle returned to its former state after therapeutic intervention¹⁾.

One study showed that not only the multifidus of CLBP patients atrophied, but another showed that their paraspinal muscles and psoas major were reduced as well^{4, 7)}. Reduction of the Cross-sectional areas (CSAs) of paraspinal muscles was caused by spinal instability and progressive spine dysfunction, and paraspinal muscle atrophy was associated with LBP^{5, 15, 16)}. Comparisons of the atrophy of the paraspinal muscles between healthy controls and CLBP patients and investigations of the atrophy of the left and right multifidus muscles in LBP patients had been focused on in previous studies^{4, 6, 7)}.

Spinal stabilization exercise is primarily used in CLBP patients to relieve pain and decrease^{11, 12)}. Studies related to clinical signs such as the increase in CSAs of the paraspinal muscles using image devices, and related to pain and lumbar disability or improvement of atrophy of the multifidus muscle account for the greater part of the research on this topic¹⁷⁻¹⁹⁾.

The purpose of this study was to determine the effect of spinal stabilization exercise on the prevention of atrophy in the multifidus and psoas major muscles, reducing pain and disability, and increasing paraspinal muscle strength in DDD patients. The effect of the exercise was determined through measurement of cross sections of the multifidus and psoas major muscles by using CT technology.

SUBJECTS AND METHODS

Thirty-three persons (14 males, 19 females) ranging in age from 25–68 who were diagnosed with DDD at the level of L4 and L5 and were listed as outpatients of W Hospital in Seoul from Nov 2011 through Oct 2012 participated in this study. A pretest-posttest design was chosen to determine the effect of spinal stabilization exercise on patients with degenerative disc disease. Only patients who were symptomatic for over 20 weeks and who had LBP without radiating leg pain were included. The ethics committee of the hospital approved the study. All the included patients were given a clinical explanation of the study, and all signed an informed consent form (Table 1).

The 33 patients were given questionnaires (self-reported form) to determine their pain score using the visual analogue scale (VAS) and their lumbar function using the Oswestry Disability Index (ODI). After the experiment, the same questionnaires were given.

Paraspinal muscular strength was measured using a CENTAUR 3D Spatial Rotation Device (BFMC, Germany). Using this machine, the paraspinal muscular strength test was conducted at 4 angles (0, 90, -90, 180). A “+” indicated the clockwise direction, while a “-” indicated the

counterclockwise direction. Muscle strength was automatically calculated by the computer with the maximal torque at the time of suspending the test. The test was immediately suspended if the patient either complained of pain or was unable to stand. The test was performed again after the experiment in the same manner²⁰⁾.

The CSAs of the deep muscles were measured by computerized tomography (Siemens, Munich, Germany). The subjects were told to keep their weight evenly at both sides in the supine position with the back of their knees propped up by cushions. In the aforementioned posture, the L4 upper end plate was photographed, and the CSAs of the left and right psoas major and left and right multifidus were measured. The CSA was measured twice by a radiologist with plenty of clinical expertise using axial images captured before and after the experiment, program was exploited by PACS (Mediface, Seoul, Korea), computer image saving and transmitting program, region of interest (ROI), and gray scale histogram. An outline was drawn around the psoas major and multifidus muscles to avoid fat, skeleton structures, and other flexile tissues. The pictures were enlarged uniformly to 152.28% in order to obtain accurate circumferences for the psoas major and multifidus. Roughly 55–60 points selected on average depending on the size and shape the muscle. The total of CSAs of the left and right psoas major and multifidus muscles were calculated automatically in mm² by computer²¹⁾.

Spinal stabilization exercise began with a fixed bicycle ride for 10 minutes as a warm-up, and then about 25–30 minutes of main exercise were performed using the CENTAUR 3D Spatial Rotation Device, ball maneuvers, or mats, including exercise to strengthen the psoas major muscle. The intensity level of the exercise was raised by 30–40% of the max intensity in weeks 1–4 weeks and by 40–50% of the max intensity in weeks 4–8. Stretching was conducted for 10 minutes for cooling down. It was a stretching program for the quadriceps, psoas major, quadratus lumborum and calf muscle. The exercise was performed for about 45–50 minutes, twice a week for 8 weeks. All exercise were conducted under the direction of a supervisor. All measurements were taken by the same person.

Intratester reliability was tested by repetitive measurement with the same protocol, and the intraclass correlation coefficient (ICC) of the CSA was 0.95. The reason why it showed an ICC with such high test-retest reliability was because the tests were conducted twice by the same researcher. Statistical analyses of the findings were performed with the SPSS for Window v. 18.0 software program. A paired t-test was used to test the difference between the paired measurements of CSA, VAS, ODI, and paraspinal muscle strength in individual patients. A significance level of $p < 0.05$ was set.

RESULTS

The changes in clinical symptoms are shown in Table 2. After conducting spinal stabilization exercise for 8 weeks, the pain associated with DDD decreased significantly from 6.12 before exercise to 2.43 after exercise ($p < 0.01$), and limitation of daily living decreased significantly, as shown by the significantly decreased in ODI from 20.18 before exercise to 8.81 after exercise ($p < 0.01$). The changes in CSA of the deep muscles after spinal stabilization exercise for 8 weeks in the 33 DDD patients are shown in Table 3. The size of the right multifidus increased significantly from 386.09 mm² before exercise to 411.85 mm² after exercise ($p < 0.01$). The size of the left multifidus increased significantly from 386.07 mm² before exercise to 410.59 mm² after exercise ($p < 0.01$), and the size of both psoas major significantly increased by as much as 36.03 mm² and 31.04 mm² respectively after exercise ($p < 0.01$). The CSA of the multifidus was relatively more increased than that of the psoas major.

The Changes in paraspinal muscle strength before and after the study are shown in Table 4. Muscular strength at all 4 angles increased after exercise compared with the pre-exercise levels ($p < 0.01$). Muscular strength at 180° was increased by more than at any of the other angles, from 42.68 Nm before exercise to 57.30 Nm after exercise ($p < 0.01$). The muscular strengths at the rest of the angles, 0°, 90°, and -90°, were increased significantly by as much as 5.56 Nm, 8.49 Nm, and 8.92Nm, respectively, after exercise compared with before exercise ($p < 0.01$).

DISCUSSION

The results of this study showed that spinal stabilization exercise had a positive effect on DDD patients in reducing pain and lumbar disability, preventing atrophy of multifidus and psoas major muscle, and increasing paraspinal muscle strength. A recent study reported that spinal stabilization exercise was an effective method relieving pain and improving function for LBP patients, since it was focused on strengthening the deep intrinsic muscles such as the multifidus, psoas major, transversus abdominis, and obliquus internus abdominis¹³. Because the deep intrinsic muscles of the spine reinforced excessive rotation and dislocation at the intervertebral level, the effective workings of such muscles improved the stability of intervertebral discs, while strengthening the multifidus for stabilizing lumbar segments reduced pain and lowered recurrence rate of LBP^{3, 14}.

Several previous imaging studies reported evidence of multifidus, psoas, and paraspinal muscle atrophy in patients with LBP^{4, 5, 7}. In a study concerning atrophy of the multifidus and psoas major of unilateral LBP patients, atrophy of the multifidus was seen in 80% of LBP patients using MRI. It was shown that the CSAs of the psoas, multifidus, paraspinal muscles, and quadratus lumborum of CLBP patients were smaller than those of healthy subjects⁷. In another study using CT Scans, the atrophy of the multifidus at the L4 upper end plate was more serious¹⁷. Even in studies using ultrasound, unilateral atrophy was found in acute and subacute LBP patients¹; the CSAs of the multifidus at L4 and L5 of chronic LBP patients were reduced, with the

Table 2. Outcome of clinical variables

Parameter	Pre-test	Post-test	t-test
VAS of LBP	6.12±1.24	2.43±1.14	*
ODI	20.18±7.14	8.81±5.73	*

VAS, visual analogue scale; ODI, Oswestry Disability Index
* p-value <0.05, paired t-test

Table 3. CSA of the multifidus and psoas major muscles in DDD patients (mm²)

Parameter		Pre-test	Post-test	t-test
Cross-Sectional areas	RM	386.1±77.8	411.9±94.3	*
	LM	386.1±78.3	410.6±91.1	*
	RP	893.0±311.5	929.0±335.6	*
	LP	872.5±334.0	907.9±343.8	*

RM, Right multifidus; LM, Left multifidus; RP, Right psoas; LP, Left psoas

* p-value <0.05, paired t-test

Table 4. Outcome of paraspinal muscle strength

Parameter		Pre-test	Post-test	t-test
CENTAUR	0°	72.8±21.1	78.4±19.0	*
	90°	68.9±17.7	77.3±17.7	*
	180°	42.7±11.5	57.3±15.7	*
	-90°	69.3±19.8	78.2±17.0	*

0°, erector spinae, multifidus; 180°, rectus abdominis and internal/external oblique ;

90°, right internal oblique; -90°, left internal oblique

* p-value <0.05, paired t-test

greatest difference at the level of L5²²). This meant that local muscle atrophy for chronic LBP patients occurred more than general muscle atrophy.

It was also reported that in some cases of LBP, atrophy of the multifidus and psoas major had a positive correlation with pain⁴. There is some evidence that the CSA of the paraspinal muscles of CLBP patients reduced gradually⁷. The CSA of the multifidus of LBP patients reduced without changing that of the psoas major¹⁶; conversely, the CSAs of the psoas major of herniated nucleus pulposus and LBP patients were significantly reduced in another study⁵.

Therefore, this study focused on the effect that spinal stabilization exercise had in influencing some clinical signs and symptoms such as the CSAs of the multifidus and psoas major in DDD patients and associated pain on the basis that atrophy of the multifidus and psoas major was present in preceding studies.

The psoas major together with the transversus abdominis and multifidus played an important role in providing spinal stabilization, and atrophy of the psoas major was positively related with pain⁴. Clinically, stretching of the psoas major has been used to treat lumbar spine disorder, leading to increased mobility of the spine²³. However, since those authors concentrated on stretching of the psoas major only as a purpose of treatment, the effect of selective muscle

strengthening of the psoas major on improving symptoms of LBP patients was not established. It appeared that as excessive contraction of the psoas major might increase intervertebral disc pressure, the focus was mainly placed on stretching rather than strengthening exercises.

As a result of strengthening the psoas major in the spinal stabilization exercise program including stretching exercise in this study, the CSA of the multifidus (right, 6.67%; left, 6.35%) was also increased, along with that of the psoas major (right, 0.43%; left, 4.05%), and pain was reduced (60.29%). This meant that spinal stabilization exercise including appropriate strengthening exercise for the psoas major might be effective for rehabilitation of DDD patients; the difference in the increase in CSA between the two muscles was because that implement was used to strengthen multifidus, while simple isometric exercise was applied to the psoas major.

Some recent studies have shown no significant effect of spinal stabilization exercise for chronic LBP patients. They argued that spinal stabilization exercise for nonspecific LBP patients showed no difference compared with other therapeutic approaches in terms of pain relief and in recurrence of LBP^{24, 25}).

The present study was limited to patients who were diagnosed with DDD and limited to chronic LBP patients with a duration of illness of over 5 months. Furthermore, it remains unclear whether or not the special spinal stabilization exercise was more effective for rehabilitation of the spine than a general physical exercise program. However, there is a great deal of recent work showing that spinal stabilization is important^{14, 26}). There is also a great deal of evidence showing that the spinal stabilization exercise is more effective than a general physical exercise program; thus, spine rehabilitation exercise should be included in general spinal stabilization exercise programs¹⁴).

This study had a number of limitations. The study sample size was small, devoid of a control group, and was not able to show if the spinal stabilization exercise in the DDD patients was more effective than the other therapeutic approach. Therefore, it is necessary to study the effect of spinal stabilization exercise, including the influence of exercise and strengthening of the psoas major muscle, on the rehabilitation of DDD patients together with the effects on a control group adopting other therapeutic methods in the future.

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