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The Effect of Lumbar Strengthening Exercise on Pain and the Cross-sectional Area Change of Lumbar Muscles

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Abstract. [Purpose] This study attempts to investigated the effect of a lumbar strengthening ball exercise on the pain of patients who have chronic lower back pain and the cross-sectional area changes in their lumbar muscles. [Subjects] The research subjects were of 33 patients with chronic lower back pain who were divided into two groups: a ball exercise therapy group (BETG, n = 17) and a conservative physical therapy group (CPTG, n = 16). [Methods] A visual analogue scale (VAS) was used to assess the recovery of patients with chronic lower back pain, and computed tomography (CT) images were analyzed to examine the cross-sectional changes of their lumbar muscles. [Results] An Compared to before and after treatment, pain of the BETG and CPTG was decreased. The cross-sectional size of the lumbar muscles significantly increased in the BETG after the treatment while the CPTG did not show a significant difference between before and after the treatment. [Conclusion] We believe that ball exercise therapy is an effective intervention that can reduce the pain of patients with chronic lower back pain and strengthen their lumbar muscles.
Key words: Ball exercise, Cross-sectional area, Chronic lower back pain

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INTRODUCTION

The occurrence rate of lower back pain continues to increase. It is affecting younger generations and its severity is also increasing[1)].

Patients with chronic lower back pain suffer from low mobility with reduced flexibility in the lumbar area and weakened muscle strength and endurance. A decline in lumbar functions can be linked to lumbar muscle pain and exhaustion among patients with chronic lower back pain. It is known that strengthening the lumbar muscles is essential for the relief of lower back pain[2)]. Mather argued that exercise is an economical and efficient treatment method to reduce disability and pain[3)]. Exercise therapies are based on the relationship between muscle tension and muscle contraction speed and they provide a safe and easy way to relieve the imbalance in muscle strength, aid recovery of muscle damage, and increase functional enhancement[4)]. Studies have shown that exercise with a ball has an expected benefit of developing muscle strength around the lower back and increases lower back flexibility, coordination, lower back endurance, proprioceptive facilitation, results in an exercise effect on the cardiovascular system[5)] Liebenson reported that continued ball exercise can contribute to stability of the spine[6)].

Weakening strength and imbalance of the lower back muscles are detrimental factors for both athletes and non-athletes. These factors disturb sport activities and daily routines due to the insufficient muscle strength and limited activity range as a result of lower back pain[7)]. As such, skeletal muscles play an important role in determining the activity capability of human beings. Hence, the field of evaluation and management of functional changes in skeletal muscles is one of the major research areas of physical therapy[8)]. Studies that examine the structural properties of skeletal muscles, such as muscle fiber size, thickness, and shape, are very important[9)].

Deyo et al. pointed out that for patients with chronic lower back pain, the reduced cross sectional area of the muscles surrounding the spine and the resulting muscle contraction can worsen the lower back pain and even cause secondary damage or recurrence[10)]. The decrease of the cross-sectional area of the muscles surrounding the spine among patients with chronic lower back pain has been confirmed by MRIs and CTs[11)]. With Advances in the technology of diagnostic imaging equipment, are enabling quantitative studies of skeletal muscle structure are being performed with high-resolution imaging and digital image analysis systems[12,13)].

In this study we conducted ball exercise therapy for

Table 1. Ball exercise program

Order	Exercise
warm-up (5min)	stretching
main exercise (30–35min)	ball push up, ball alternating superman ball roll out, ball side crunch ball bridge, reverse ball bridge ball crunch-legs elevated, ball sit up ball back extension, ball arm-leg extension alternating
cool-down (5min)	stretching

patients with chronic lower back pain for 12 weeks and investigated its effects on the lower back pain relief and analyzed the cross-sectional changes of their lumbar muscles using CT images.

SUBJECTS AND METHODS

The research subjects were of 33 patients who were diagnosed with chronic lower back pain by a neurologist at Hospital P located in Daegu, South Korea. The subjects were divided into two groups: 17 in the ball exercise therapy group (BETG) and 16 in the conservative physical therapy group (CPTG). The participants in the BETG had an average age of 32.7 ± 5.9, height of 169.0 ± 8.6 cm, and weight of 64.6 ± 17.6 kg, while those in the CPTG had an average age of 33.1 ± 5.7, height of 165.9 ± 8.6 cm, and weight of 61.2 ± 11.8 kg, Two groups with no statistically significant differences ($p>0.05$), satisfying the homogeneity between the two groups. The sample excluded those who had any of the following disease history of back surgery, mental illness or neurologic disability, unexpected falls during the last six months, brain disease, rheumatoid or spinal arthritis, or contraindication for electrical therapy were excluded from the study. The research subjects were patients who volunteered after being explained the purpose of the experiment and its whole procedure.

For the ball exercise therapy, a Gymnastik Ball (Togu, Germany) was used. The size was chosen following the manual of the maker, Togu. (Person's height: shorter than 155 cm = ball size: 45 cm; 156–165 cm: 55 cm; 165–178 cm: 65 cm; and taller than 178 cm: 75 cm). Rate of Perceived Exertion (RPE) was set at 11–13 (fairly light-somewhat hard) during the first 8 weeks, followed by 13–15 (somewhat hard-hard) for the 9th to 12th weeks. The frequency of exercise was three times a week for 12 weeks and each session lasted 40–45 minutes. Each position was maintained for 5 seconds, followed by 2–3 seconds of resting. The session was composed of 3 sets with 10 repetitions of each exercise. Table 1 summarizes the exercise scheme.

Conservative physical treatment, including moist heat treatment (20–25 minutes), ultrasound therapy (5 minutes, 1.5 W/cm^2), and transcutaneous electrical nerve stimulation (TENS, 20 minutes at 4 PPS and strength of recognizable muscle contraction), was performed three times a week for 12 weeks.

A visual analogue scale (VAS) was used to assess the extent experienced by patients before and after treatment. The scale had a range of 0–10 on which 0 indicates no symptom of pain and 10 indicates severe persistent pain that interferes with daily routine. The difference in the cross-sectional size of the lumbar muscles was measured by analyzing the CT(WCT-200-120/TSX-001A; Toshiba, Japan) scanned images taken at the L4-5 level before and after treatment. The cross-sectional area of each muscle was computed by a built-in computer program of CT that recognizes the area of relevant muscle in a scanned image sliced at the L4-5 level.

Measured data we used the paired t-test and Wilcoxon's signed rank test for comparisons of pain in before and after, and change in lumbar muscle cross-sectional area before and after treatment, and the comparison of the means of the cross-sectional area of the lumbar muscle of each group. SPSS 12.0 for Windows was used for the statistical analysis with a significance level of $\alpha = 0.05$.

RESULTS

The VAS of BETG and CPTG were statistically significantly different in before and after of treatment (Table 2). According to the comparison results of the lumbar muscles' cross-sectional changes shown on the CT were significantly greater treatment in the BEGT in the cross-section of every lumbar muscle while those of the CPTG showed no statistically significant differences (Table 3). Moreover, there was a statistically significant difference between the two groups in their mean cross-sectional areas of the lumbar muscles after treatment (Table 4).

DISCUSSION

This study examined how lumbar strengthening ball exercise affects the pain of patients who have chronic lower back pain as well as changes in the cross-sectional area of the lumbar muscles. Hides et al. argued that the multifidus of lumbar is not capable of natural recovery once it has been weakened, and the ensuing lack of local stability of the local area becomes one of the factors responsible for the recurrence of lower back pain[14]. Cooper et al. compared the ratio of the cross-sectional area of the paraspinal muscle to that of the psoas muscle between 43 acute lower back pain patients and 44 patients with chronic lower back pain using radiography at the L4 spinal level. Their results indicated that the ratio for chronic patients is significantly less than

Table 2. The comparison of pre- and post- intervention VAS of the each groups (Mean ± SD)

Group		Pre	Post
BETG* [a]	†[b]	5.88 ± 1.93	1.29 ± 1.10
CPTG*	†	5.63 ± 1.99	2.06 ± 1.48

*, † $p<0.05$, [a]: T-test, [b]: Non-parametric test. BETG: Ball exercise therapy group, CPTG: Conservative physical therapy group.

Table 4. Between-group comparison of differences of cross-sectional area of each lumbar muscles (unit: mm^2)

Muscle	BETG (Post-pre)	CPTG (Post-pre)
PM*	65.53 ± 53.62	5.89 ± 17.18
QL*	29.29 ± 29.00	1.61 ± 8.90
ES*	112.59 ± 54.96	1.01 ± 20.32
MT*	121.00 ± 42.97	3.33 ± 18.33

*$p<0.05$.

compared that of the acute patients. This reduction in the muscle ratio is reflect weakness of the muscles and instability of the spine[15].

O' Sullivan et al. examined the effects of lower back stabilizing exercise with a sample of 44 patients with chronic lower back pain due to spondylolysis and spondylolisthesis. The experimental group executed strengthening exercise of the transversus abdominis and multifidus for ten weeks while the control group received traditional physical therapy. O' Sullivan et al. reported that the experimental group showed significant pain relief and functional enhancement 30 months after the experiment while the control group showed no such change[16]. This result is different from that of our study in which VAS significantly decreased both in the BETG and CPTG 12 weeks after the treatment. However, the results are similar in that the BETG showed significant pain relief and functional enhancement together with an increase in each muscle's cross-section. Moreover, our results are consistent with those reported by Hides et al.'s experiment result in: "Effect of stabilization training on multifidus muscle cross-sectional area among young elite cricketers with low back pain". They examined the cross-section of the L5 level multifidus using ultrasound imaging. In experiment, seven cricketers who performed stabilizing exercise after a 12-week training camp. The subjects showed a significant increase in the multifidus compared to 14 cricket players who did not receive rehabilitation treatment. The pain level of the treated cricketers, as measured by VAS, was also reduced by 50%[17].

Above study support the result in this study a significant increase in the difference of cross-sectional area of the lumbar muscle was seen after treatment in BETG group. The ball exercise is performed to increase muscular strength, endurance, flexibility, nerve reflexes, perception, sense of balance, and proprioceptive sense with dynamic stabilization therapy for muscle activity[18]. The ball exercise

Table 3. The comparison of Cross-sectional area of each lumbar muscles in the each groups (unit: mm^2)

Group	Muscle	Pre (Mean ± SD)	Post (Mean ± SD)
BETG	PM* [a] †[b]	1274.24 ± 412.54	1339.76 ± 407.79
	QL* †	629.15 ± 162.92	657.28 ± 161.26
	ES* †	1689.44 ± 522.75	1802.02 ± 537.96
	MT* †	830.93 ± 225.22	951.94 ± 256.84
CPTG	PM	1245.62 ± 308.10	1251.51 ± 312.02
	QL	591.38 ± 90.25	1611.73 ± 295.81
	ES	1611.73 ± 295.81	1612.74 ± 301.84
	MT	796.99 ± 138.41	800.32 ± 139.99

*,†: $p<0.05$, [a]: T-test, [b]: Non-parametric test. PM: Psoas major, QL: Quadratus lumborum, ES: Erector spinae, MT: Multifidus.

therapy is an efficient intervention for improving the strength of intrinsic and lumbar muscles that can protect the spine of patients with chronic lower back pain. Moreover, the statistically significant difference in the cross-sectional area of the lumbar muscles after treatment between the two groups implies that lumbar strengthening exercise is essential for patients with chronic lower back pain and that conservative physical treatment alone is insufficient for improvement of lumbar muscle strength.

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