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The Effects of Resistivity and Stability-Combined Exercise for Lumbar Muscles on Strength, Cross-Sectional Area and Balance Ability: Exercises for Prevention of Lower Back Pain

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Abstract. [Purpose] The purpose of this study was to investigate the effects of a resistance and stabilization complex exercise on the strength and cross-sectional area of lumbar muscles of typical adults in their twenties. [Subjects and Methods] For this study, 14 male adults in their twenties were chosen and randomly assigned to either the resistance exercise group (REG, n=7) or the resistance and stabilization exercise group (RSEG, n=7). They then exercised for 50 minutes three times a week for 8 weeks. [Methods] Pegasus was used to measure the strength of the lumbar muscles of the normal adults and computed tomography (CT) images were taken and compared to examine the changing cross-sectional areas of the lumbar muscles. [Results] Both groups showed a significant increase in the strength of their lumbar muscles. For the cross-sectional area of the lumbar muscles, only the superficial stabilizer muscle of the REG group showed a significant increase, whereas both the superficial stabilizer and the deep stabilizer muscles of the RSEG group showed a significant increase. [Conclusion] The resistance and stabilization complex exercise for the lumbar muscles had positive effects on both the strength of the lumbar muscles as well as on the cross-sectional areas of the superficial stabilizer and deep stabilizer muscles. Therefore, resistance and stabilization complex exercise appears to be an effective exercise program for the prevention of lower back pain.
Key words: Back pain, Resistance exercise, Lumbar stabilization exercise

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INTRODUCTION

The stability of the lumbar region, which is at the center of the body, is known to be helpful for the efficiency and prevention of injuries in complex exercises and for the general functional activities of the body[1)]. In modern society, preventive medicine is being given greater importance than therapeutic medicine. For prevention of lower back pain, it is absolutely necessary to strengthen the lumbar muscles.

Lumbar muscles are divided into the deep stabilizer muscle and the superficial stabilizer muscle. The superficial stabilizer muscle is used to respond to swaying and the deep stabilizer muscle is used to maintain a posture against swaying[2)]. Lower back pain is caused by the wrong mobilization sequence between the superficial stabilizer and deep stabilizer muscles and an imbalance in the muscular lengths[3)]. Thus, in order to stabilize the lumbar muscles, the cooperative contraction of the superficial stabilizer and deep stabilizer muscles and the strengthening of the deep stabilizer muscle which is directly connected to the spine are needed[4)].

A method for strengthening the lumbar muscles used in both the sports and the clinical fields is resistance exercise which has been reported to be effective for the improvement of lower back pain, functional disorders and the functions of the lumbar muscles[5)]. But Studies of resistance exercise for the superficial stabilizer muscles have shown that it does not affect the deep stabilizer muscles have been studied[6)].

Furthermore, stabilization exercises are frequently applied in clinical settings these days and have been reported to be effective for increasing the strength of the lumbar muscles[7)]. However, stabilization exercises affect the deep stabilizer muscles, but they do not significantly affect the superficial stabilizer muscles[8)].

Muscle strength is proportional to the cross-sectional area of the muscles if adaptation is excluded. Patients with chronic lower back pain exhibit the severest weakening of the deep stabilizer muscle[9)]. If the weakening of the deep stabilizer muscle is neglected it does not improve by itself and it needs to be strengthened through stabilization exercises which are appropriate for this condition[10)].

Thus, we can see that both the superficial stabilizer and deep stabilizer muscles need to be strengthened to prevent lower back pain. Most previous studies have been centered on the rehabilitation of patients and studies on the prevention of lower back pain for the general public are still insufficient. This study is intended to investigated the effects of a resistance and stabilization complex exercise on the strength and cross-sectional area of the lumbar muscles for the prevention of lower back pain of typical adults.

SUBJECTS AND METHODS

For the subjects of this study, 14 male adults in their twenties were chosen and randomly assigned to either the resistance exercise group (REG, n=7) or the resistance and stabilization exercise group (RSEG, n=7). The average age, height and weight of the REG were 26.57 ± 1.81, 174.64 ± 4.24 cm, and 77.21 ± 4.58 kg, respectively. Those of the RSEG were 26.40 ± 1.13, 173.38 ± 5.07 cm, and 75.40 ± 5.62 kg, respectively. There was no homogeneity problem between the two groups were homogeneous because they showed no statistically significant differences ($p>0.05$). The subjects were selected from candidates who had no experience of regular exercise at least twice a week within the last six months, no experience of surgery related to musculoskeletal diseases, no diagnosis of lower back pain and who consented to participate in the study. The resistance exercise program consisted of five exercises using MedX Abdominal, MedX Hip Extension, MedX Torso Rt Rotaro, MedX Torso Lt Rotaro, and MedX Torso Flexion (Medx, USA). For the exercise level, 1RM (the maximum weight that can be lifted without pain) was measured for each exercise and the subjects did 4 sets of exercises of 10–14 cycles at the 70% level of 1RM. The duration for each set of exercises was 30–40 seconds and the break time was 1 minute. The exercise level was increased by 3 cycles after 2 weeks. After 4 weeks, 1RM was measured again, and the subjects did 4 sets of exercises in 10–12 cycles at 70% of 1 RM. After 6 weeks, the exercise level was increased by 3 levels again.

The resistance and stabilization for complex exercise was performed in the same way as for the resistance exercise described above. For the stabilization exercise program, the subjects did 6 kinds of exercises including raising arms or legs in the bridging posture on a mat, raising arms or legs in the crawling posture, raising buttocks with legs hanging in sling exercise equipment and moving the upper body forward whilst holding the sling with their arms. For the exercise level, the weak link was found and the subjects did 1 set of exercises for 10 cycles under the guidance of a physical therapist. In each set, they posed in a neutral posture[11] while contracting their transverse abdominis and pelvic floor muscles and returning to the original position in 4–5 seconds and then maintaining it for 5–6 seconds. During the pelvic floor muscle contractions, tighten up only the sphincter muscle except for the contraction of thegluteus muscles only the sphincter muscle was tightened. And When the transverse abdominis contracts, the navel is drawn to the spine. The duration of each set of exercise was 90–100 seconds and the break time was 1 min. If the subject could do it without difficulty, the exercise level was increased by 2 cycles after 2 weeks, and after 4 weeks, the exercise level was increased to two sets of 10 cycles on an AIRREX mat; after 6 weeks, the exercise level was again increased by 2 cycles. The strength of the lumbar muscles was measured using the Pegasus 3-D system (BFMC: Biofeedback Motor Control GmbH, Germany) before exercise, after 4 weeks and after 8 weeks. For this measurement, the subjects were given sufficient instruction about the test process and they were then asked to sit and not move their arms, pelvis, femur or knees. To relieve the acclimatize themselves to repulsion to the measuring equipment, they performed a submaximal contraction twice to adapt to the equipment and were given sufficient rest before two measurements of the maximal isometric contraction twice which were then averaged.

For the measurement of the cross-sectional area of muscles, the top part of the L4 cone was scanned with computed tomography (Shimadzu, Japan) at a power of 120 kv, 240 mA for one second in the size of 512 × 512 pixels (Fig. 1). The cross-sectional area of the muscles in the ROI (regions of interest) was measured on a monitor of a picture achieving and communication system (PACS) monitor in P Hospital along the boundary between the multifidus muscle which is a deep muscle and the paraspinal muscle which is a superficial muscle in the Hounsfield unit of 30 and 65. The mean of the left and right cross-sectional areas of the spine measured in the CT images was converted to actual area (mm^2). To calculate the mean (M) and standard deviation (SD) of the results of each variable and to analyze the differences in the lumbar muscular strength and balance by exercise type and time, a two-way ANOVA with repeated measures was performed. When a significant difference between the different times or exercise types was found, an independent sample t-test was conducted for post-verification method and a contrast test was conducted for verification between different times for each exercise type. For the change of the cross-sectional area of the lumbar muscles, a two-way ANOVA was conducted followed by a paired sample t-test. For statistical processing, SPSS 12.0 Windows was used and the significance level α was set to 0.05.

RESULTS

Both the REG and RSEG showed significant increases in the muscle strength of lumbar flexion, extension and left and right rotations, but there was no significant difference between the two groups (Table 1). Regarding the cross-sectional area of the lumbar muscles, the cross-sectional area of the paraspinal muscle significantly increased in the REG ($p<0.05$), but no significant change was observed in the multifidus muscle. For the RSEG, the cross-sectional areas of both the paraspinal and multifidus muscles increased significantly ($p<0.05$) (Table 2).

DISCUSSION

When a sudden load is applied to the body during the

Table 1. The changes in Lumbar muscle strength (Mean ± SD) [Nm]

Item	Group	Before exercise	After 4 weeks	After 8 weeks
Flexion	REG(n=7)*	94.90 ± 29.02	110.77 ± 29.80	122.84 ± 33.39
	RSEG(n=7)*	65.76 ± 10.59	87.20 ± 16.43	108.70 ± 34.41
Extension	REG(n=7)*	231.97 ± 52.64	264.31 ± 80.38	277.59 ± 88.16
	RSEG(n=7)*	298.24 ± 60.50	340.96 ± 43.67	347.40 ± 47.62
Left rotation	REG(n=7)*	108.08 ± 25.89	122.67 ± 25.39	132.55 ± 24.39
	RSEG(n=7)*	110.04 ± 27.10	131.34 ± 18.93	152.18 ± 26.81
Right rotation	REG(n=7)*	118.72 ± 23.34	126.45 ± 23.39	135.35 ± 22.47
	RSEG(n=7)*	113.oo ± 28.88	136.15 ± 31.30	155.35 ± 23.50

* $p<0.05$, REG: Resistance exercise group, RSEG: Resistance & Stabilization exercise group.

Table 2. The cross-sectional area change of multifidus and paraspinal muscles (Mean ± SD) [mm^2]

Item	Group	Before	After
multifidus	REG(n=7)	716.95 ± 146.39	803.15 ± 204.52
	RSEG(n=7)*	672.57 ± 135.80	787.52 ± 150.21
paraspinal muscle	REG(n=7)*	5921.68 ± 454.67	6274.73 ± 507.31
	RSEG(n=7)*	5536.54 ± 346.82	6251.50 ± 528.13

* $p<0.05$.

movement of the body, the resulting instability of the lumbar region can not only hinder movement ability but can also cause an injury to the lumbar region as well as to the legs. Therefore, it is important to strengthen the lumbar muscles[12]. The strength of the lumbar muscles is the key to the stability of the lumbar region. The lumbar muscles are divided into the deep stabilizer muscle and the superficial stabilizer muscle and the lumbar region exhibits greater power when the superficial stabilizer muscle, which is a large muscle, and the deep stabilizer muscle, which is a local muscle, are strengthened. Therefore, lumbar stability based on the strength of the lumbar muscles is required to prevent lower back pain[4]. In this study, the muscular strength of the REG significantly increased in all measurements including flexion, extension and left and right rotations ($p<0.05$). This is identical to the results of previous studies[13,14] which found that resistance exercise improved muscular strength. This result seems to be related to the strengthening by resistance exercise of the erector spinae muscle, rectus abdominis muscle, and internal and external oblique abdominal muscles, which are superficial stabilizer muscles.

The muscular strength of the RSEG also significantly increased over time in all measurements ($p<0.05$). The multifidus muscle plays the greatest role in the neutral posture and in stabilization whilst in flexion, and in extension and axial rotations[15]. A study of the effects of the resistance and stabilization complex exercise for women in their twenties with chronic lower back pain also reported that their strength of lumbar muscles increased[16], which is identical to the finding of this study. This result implies that the resistance and stabilization complex exercise program

Fig. 1. Lumbar muscular cross-sectional area test. M: multifidus, P: paraspinal muscle.

stage of the resistance exercise, the cross-sectional area of the muscles did not increase. Until the 4th week, which is the early stage of the training, the strength of the muscles increased more through the adaptation of the nervous system than through the increase in the cross-sectional area of the muscles. The increase in the strength of the muscles by the increased cross-sectional area only appeared after 8 weeks. The tensile force of muscles is proportional to the cross-sectional area of the muscles if there is no problem in the adaptation of the nervous system[18,19].

This study analyzed the multifidus muscle which is a deep stabilizer muscle and the paraspinal muscle which is a superficial stabilizer muscle of the lumbar muscles using CT after the lumbar muscle strengthening exercise and found that the cross-sectional area of only the superficial stabilizer muscle increased in the REG. A study of patients with lower back pain and contraction in paraspinal muscles who had exercised for 10 weeks reported that stabilization exercises do not have any effect on the cross-sectional area of paraspinal muscles and the strong resistance exercise was required to strengthen the paraspinal muscles[6]. In other words, the resistance exercise for the lumbar region seems to have influenced the increase in the cross-sectional area of the paraspinal muscles which have many type II fibers. Furthermore, it was reported that special exercise, or stabilization exercise was needed to strengthen the multifidus muscles[10] and this suggests that stabilization exercise is needed to strengthen the deep stabilizer muscles.

In this study the RSEG experienced an increase in cross-sectional areas of both the superficial stabilizer and deep stabilizer muscles. A study reported that after 10 weeks of stabilization exercise, resistance and stabilization complex exercise and stabilization and static/dynamic complex exercise for patients with chronic lower back pain, the stabilization exercise group did not show any increase in the cross-sectional area of the paraspinal muscles, but it did significantly increased in the other two groups which performed resistance exercises[6]. Another study also conducted exercises with the same groups and reported a significant increase in the cross-sectional area of the multifidus muscles in the group which included stabilization exercises,[20] which supports the result of this study. In the RSEG, the resistance and stabilization complex exercise appears to have influenced both the multifidus and paraspinal muscles through the stabilization and resistance exercises, respectively. In modern society, the incidence of lower back pain is increasing and the onset age is reducing. This Lower back pain is mainly caused by the weakening and instability of the lumbar region. In this study, even though there was no statistical significance in the difference in the strength and cross-sectional area of the lumbar muscles after the exercise program the two groups, the RSEG exhibited a significant difference in the cross-sectional area of both the superficial stabilizer and deep stabilizer muscles after the exercise program. Therefore, the resistance and stabilization complex exercise can be an effective exercise program for the prevention of lower back pain. Later, long-term study will continue to be done through many of the subjects. Also, Multilateral studies, which is subdivided by age, gender, occupation and disease, are also necessary.

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