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Effects of Lumbar Resistance and Stabilization Complex Exercises on Extremity Muscle Strength and Endurance of Normal Adults

JONGWOO KIM, PhD, PT[1)], WONTAE GONG, PhD, PT[2)], BYEONGJUN HWANG, PhD, PT[3)]

[1)] *Department of Physical Therapy, Deagu Park Hospital*
[2)] *Department of Physical Therapy, Gumi College: 407, Bugok-dong, Gumi-si, Kyoungbuk, 730-711 Republic of Korea. TEL +82 54-440-1244, FAX: +82 54-440-1179, E-mail: owntae@hanmail.net*
[3)] *Department of Physical Therapy, Taegu Science College*

Abstract. [Purpose] The purpose of this study was to examine the effects of lumbar resistance and stabilization complex exercises on upper/lower extremity muscle strength and endurance of the general adult population. [Subjects] Fourteen male adults in their 20s participated. Seven persons each were randomly assigned to a resistance exercise group (REG) or a resistance and stabilization exercise group (RSEG). Exercise programs were implemented three times a week for 50 minutes for eight weeks. [Methods] The Biodex System 3 Pro was used to measure the upper/lower extremity muscle strength and endurance of the REG and RSEG prior to the intervention and at four and eight weeks following the commencement of the intervention. The results were then compared and analyzed. [Results] With regards to changes in upper/lower extremity muscle strength and endurance, both groups showed significant increases during the experimental period. The two groups also exhibited differences in muscle strength during upper/lower extremity flexion and differences in muscle endurance during upper extremity extension and lower extremity flexion. [Conclusion] Lumbar resistance and stabilization complex exercises positively affected both upper and lower extremity muscle strength and endurance. In particular, the RSEG showed larger effects than the REG. Therefore, the resistance and stabilization complex training exercises appear to be more effective for rehabilitation of the upper/lower extremities.
Key words: Rehabilitation, Resistance exercise, Stabilization exercise

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INTRODUCTION

In upper/lower extremity injuries, early approaches to rehabilitation enable a complete return to normal daily activities[1)]. However, patients experience difficulties in early rehabilitation following surgery due to factors such as fixation-related joint contracture, a limited range of motion, and reduced muscle strength[2)]. Various methods such as PNF, which aims to enhance functions of other parts of the body through lumbar exercises, have been adopted to overcome these problems. The PNF approach exerts its influence via radiating effects, which are defined as muscle activities in one area of the body inducing muscle activities in another area of the body via muscles connected to each other[3,4)]. In clinics, the approach involves imposing resistance in strong areas to promote muscle activity in other areas. Results indicate that such training on one side will affect the other side of the body. Thus, the approach is also called cross-training or opposite-side effect training[5)].

Powerful stimuli to the center of the body imposed through lumbar stabilization affect distal parts of the body. For an area of the body to work efficiently during the performance of exercises, another area of the body should serve as a fixed point[6)]. The reinforcement of the lumbar region affects the upper/lower extremities, enabling them to function efficiently[7)]. Correlations between the extremities and the lumbar region have been demonstrated in previous studies[8,9)]. According to one study, to stabilize the lumbar region, the deep stabilizer muscle and the superficial stabilizer muscle need to be reinforced[10)]. To reinforce the deep stabilizer muscle and the superficial stabilizer muscle, stabilization exercises and resistance exercises, respectively, are appropriate[11)].

However, there are few studies of the effect of lumbar stabilization—reinforcement of the deep stabilizing and superficial lumbar muscles—on upper/lower extremity muscle strength and endurance. In particular, there is a lack of appropriate exercise programs for effective rehabilitation of upper/lower extremity muscle functions in clinics. Therefore, this study aimed to examine the effects of resistance and stabilization complex exercises on upper/lower extremity muscle strength and endurance in the general adult population in order to present an effective exercise program for use in rehabilitation centers that is

Table 1. Physical Characteristics of the subjects (mean ± SD)

Group	Age (yrs)	Height (cm)	Weight (kg)	BFP (%)
REG	26.6 ± 1.8	174.6 ± 4.2	77.2 ± 4.6	22.1 ± 4.5
RSEG	26.6 ± 0.8	173.7 ± 3.7	72.9 ± 3.2	19.7 ± 3.3

REG: Resistance exercise group, RSEG: Resistance and stablilzation exercise group, BFP: Body Fat Percentage.

Table 2. Resistance exercise program

Type	Content	Program	Time taken	RT
Warm-up exercise	Stretching	1. Lumbar flexion 2. Lumbar extension 3. Lumbar left/right rotation 4. Lumbar left/right lateral flexion	10 min.	
Main exercise	Resistance exercise	1. MedX lumbar flexion 2. MedX lumbar right rotation 3. MedX lumbar left rotation 4. MedX hip joint extension 5. MedX hip joint flexion	30 minutes (1–12 times × 4 sets) Exercising time per set (30–40 sec.)	1 min per set
cool down	Breathing and aerobic exercise	1. Abdominal breathing exercise 2. Walking exercise with 30–40% of the target heart rate	10 min.	
Total			50 min.	

RT: Resting time.

capable of enhancing upper/lower extremity function.

SUBJECTS AND METHODS

Study consent was obtained from 14 adult males residing in Daegu, Korea who agreed to participate after being made aware of the purpose and content of the study. Seven of the participants were randomly assigned to the resistance exercise group (REG) and the other seven were assigned to the resistance and stabilization exercise group (RSEG). Inclusion criteria included not performing regular exercise two or more times a week within the last six months, no history past record of musculoskeletal system disease-related surgery, and no of low back pain. The physical characteristics of the subjects are shown in Table 1. In the resistance exercise program, five types of exercises were performed using MedX (USA) equipment. The program is outlined in Table 2. The 1RM (maximum weight that can be lifted without pain) of each type of exercise was measured; the subjects performed four sets of each exercise consisting of 10–12 times of the exercise at 70% intensity. The exercise time per set was 30–40 seconds, and a resting time of one minute was permitted between each set. The number of exercises per set was increased by 3, two weeks later, and the 1RM of each type of exercises was measured again at four weeks. The subjects then performed four sets of each exercise consisting of 10–12 times of the exercise at an intensity of 70% of the new 1RM. At six weeks, the number of exercises per set was increased by three.

The complex exercise program was the same as the resistance exercise except that two, rather than four, sets of each exercise were performed. The details of the program are shown in Table 3. In the stabilization exercise, the subjects had to adopt a neutral stance, in which the transverse abdominis and pelvic floor muscles were contracted for 4,5 seconds. They then had to return to the original position within 5,6 seconds. The subjects performed one set of this exercise 10 times under the guidance of a physical therapist with at least 10 years' clinical experience. The exercise time per set was 90–100 seconds, and a resting time of one minute was permitted between each exercise. To determine whether the subject could perform the exercise without strain, the intensity of the exercise was increased two weeks later by increasing the number of times of the exercise per set by two. At four weeks, the exercise was increased to two sets of 10 on a balance mat. At six weeks, the number of times of the exercises per set was increased by two. To determine upper/lower extremity muscle strength and endurance, the Biodex System 3 Pro (USA) was used to measure the upper/lower extremity muscle strength and endurance of the dominant side prior to the experiment and four and eight weeks later. The upper extremity muscle strength and endurance of the shoulder joint flexion and extension were measured using D2 diagonal flexion patterns (shoulder joint flexion, abduction, external rotation) and D2 diagonal extension patterns (shoulder joint extension, adduction, internal rotation). The lower extremity muscle strength and endurance of the knee joint flexion and extension were also measured.

Prior to the measurements, the subjects performed warm-up exercises for 10 minutes. To familiarize themselves with

Table 3. Resistance and stabilization complex exercise program

Type	Content	Program	Time taken	RT
Warm-up exercise	Stretching	1. Lumbar flexion 2. Lumbar extension 3. Lumbar left/right rotation 4. Lumbar left/right lateral flexion	10 min.	
Main excercise	Resistance exercise	1. MedX lumbar flexion 2. MedX lumbar right rotation 3. MedX lumbar left rotation 4. MedX hip joint extension 5. MedX hip joint flexion	15 min (10–12 times × 2 sets) Exercising time per set (30–40 sec.)	1 min per set
	Stabilization exercise	1. Lower extremity lifting in a bridge posture 2. Upper extremity lifting in a bridge posture 3. Lower extremity lift in a prone position on a ball 4. Upper extremity lift in a prone position on a ball 5. Moving the body forward grasping a sling in a kneeling position 6. Lifting the buttocks with the lower extremity hooked on a sling in a supine position	15 min. (10 time × 1set) Exercising time per set (90–100 sec.)	
cool down	Breathing and aerobic exercise	1. Abdominal breathing exercise 2. Walking exercise with 30–40% of the target heart rate	10 min	
Total			50 min	

the machine and the test process, the subjects repeated the exercises twice with submaximal contraction. Each subject's peak torque, which is a factor of the maximum muscle strength, was measured at 60°/sec and each subject's total work, which is a factor of muscle endurance, was measured at 240°/sec. The measurements were undertaken after the subjects had rested for two minutes after the completion of the test. While the measurements were being made, the subjects were allowed to view their results on a computer monitor, which also provided biofeedback. The researcher also encouraged the subjects to push themselves to their utmost. The resulting data were analyzed using the SPSS 12.0 KO (SPSS, Chicago, IL, USA) statistical program and are presented as means and standard deviations. Differences in upper/lower extremity muscle strength and endurance between the types and time points of exercises were analyzed by repeated two-way ANOVA. When significant differences were observed between the types of exercises at time points, the independent sample t-test was conducted as an ex post facto test. Differences in the types of exercises between the different time points were evaluated by contrast tests. The statistical significance level α was chosen as 0.05.

RESULTS

Muscle strength of upper extremity and lower extremity flexion and extension significantly increased over time in both the REG and the RSEG ($p<0.05$). Significant differences in flexion were observed between the two groups in both the upper extremities and lower extremities ($p<0.05$) (Table 4).

With regards to changes in muscle endurance of upper extremity and lower extremity flexion and extension, both the REG and the RSEG showed significant increases ($p<0.05$). Between the groups, the upper extremities showed significant differences in extension, and the lower extremities showed significant differences in flexion ($p<0.05$) (Table 5).

DISCUSSION

Exercises that focus on smoothly moving distal parts while maintaining fixed or neutral positions prevent excessive movement of the spinal segments, thereby enhancing the efficiency of functional movements of the upper/lower extremities[13]. Powerful stimuli to the center of the body also affect distal parts of the body. Therefore, for an area of the body to work efficiently, another area of the body needs to serve as a fixed point[6]. In this study, muscle strength of flexion and extension increased over time in both the REG and the RSEG. This is consistent with the results of Carpes et al. who reported that lower extremity muscle strength increased in females with chronic low back pain in their twenties who performed resistance and stabilization complex exercises for seven weeks[14]. Their finding suggests that the reinforcement of muscle strength in strong regions promotes muscle activity in weak regions, which is explained by the principle of cross-training or opposite side effects[4]. Lumbar muscle strength also increased in our study. Thus, there should have been effects to induced by cross-training that activated muscle contraction in the

Table 4. Changes in muscle strength of upper extremity and lower extremity flexion and extension (mean ± SD) (unit: Nm)

Item		Group	Before	4 weeks later	8 weeks later
Upper extremity	flexion#	REG*	66.0 ± 15.5	64.9 ± 6.9	84.6 ± 15.9
		RSEG*	70.4 ± 23.5	85.7 ± 8.8	97.4 ± 4.2
	extension	REG*	42.1 ± 12.3	45.4 ± 9.4	57.0 ± 22.0
		RSEG*	50.2 ± 14.1	55.4 ± 13.5	64.0 ± 11.1
Lower extremity	flexion#	REG*	77.1 ± 13.6	84.8 ± 5.9	84.3 ± 14.4
		RSEG*	87.2 ± 24.1	98.8 ± 14.5	110.8 ± 19.0
	extension	REG*	162.4 ± 24.4	191.9 ± 18.3	202.4 ± 12.1
		RSEG*	167.7 ± 31.8	189.6 ± 33.3	203.5 ± 30.9

*: $p < 0.05$ (period), #: $p < 0.05$ (group).

Table 5. Changes in muscle endurance of upper extremity and lower extremity flexion and extension (mean ± SD) (unit: Joule)

Item		Group	Before	4 weeks later	8 weeks later
Upper extremity	flexion	REG*	972.9 ± 401.8	1039.1 ± 381.7	1243.5 ± 215.9
		RSEG*	1079.0 ± 392.7	1178.9 ± 261.6	1480.8 ± 174.9
	extension#	REG*	459.9 ± 115.0	543.0 ± 117.8	573.9 ± 86.3
		RSEG*	522.9 ± 151.0	715.4 ± 122.7	880.4 ± 216.8
Lower extremity	flexion#	REG*	586.5 ± 197.3	652.4 ± 131.2	706.6 ± 140.6
		RSEG*	695.3 ± 81.4	945.6 ± 230.4	1050.1 ± 246.9
	extension	REG*	1741.4 ± 157.3	1812.9 ± 132.0	1841.4 ± 154.9
		RSEG*	1517.3 ± 189.8	1707.5 ± 189.5	1790.5 ± 256.6

*: $p < 0.05$(period), #: $p < 0.05$(group).

upper/lower extremities.

Compared with the REG, RSEG showed larger significant differences in upper/lower extremity flexion and muscle strength. Our results suggest that lumbar stabilization exercises through bridge exercises appear to have additional effects on the upper/lower extremities. This finding is similar to that noted in a previous comparison of the effect of trunk resistance exercises and bridge exercises on the activity of lower extremity muscles which reported that the muscle activity of the femoral muscles was significantly increased[9)]. Another study reported that the muscle activity of the erector spinae muscle decreased and that of the hamstring significantly increased during stabilization exercises[15)].

Also a study of firefighters reported that stabilization exercises helped efficiency in complicated tasks and in prevented injury[16)]. Researchers have also found that the reinforcement of upper/lower extremity muscles is associated with efficient functioning of the lumbar region and that the reinforcement of the lumbar muscles is associated with efficient functioning of the upper/lower extremities[7)].

In this study, flexion and extension muscle endurance increased over time in both REG and RSEG. In a previous study, when healthy patients and patients with low back pain performed lumbar muscle exercises to fatigue the lumbar muscles, tests of their lower extremity muscle functions showed that the degrees of fatigue of the lower extremity muscles increased in both healthy patients and those with low back pain[17)]. This suggests that lumbar muscle weakening and fatigue will affect lower extremity muscle functions, indicating that there is an inter-relationship between the muscles in the lumbar region and those of the lower extremities. Compared with the resistance exercise group, the complex exercise group showed more significant differences in muscle endurance in upper extremity extension and lower extremity flexion. In low back pain patients, researchers previously reported that the deep stabilizer muscle was weaker than the superficial stabilizer muscle[18)]. In another study of healthy patients and low back pain patients who performed lumbar muscle exercises, tests of their lower extremity muscle strength revealed more serious weaknesses in the low back pain group[17)]. Our findings suggest that the eight-week resistance and stabilization complex exercise program played a role in improving the strength endurance of the upper/ lower extremity muscles and the functioning of the deep stabilizer muscle. In conclusion, resistance and stabilization complex exercises are effective for enhancing upper/lower extremity muscle strength and endurance. Diverse studies from multiple angles should be conducted in the future.

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