



Original Article

The effect of combined exercise with slings and a flexi-bar on muscle activity and pain in rotator cuff repair patients

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Abstract. [Purpose] The purpose of this research was to determine the effect of combined exercise with slings and a Flexi-Bar on muscle activity and pain in rotator cuff repair patients. [Subjects and Methods] This research evaluated 20 rotator cuff repair patients divided randomly into groups of 10 as the control group and the experimental group. The experimental group performed combined exercise with slings and a Flexi-Bar. Both the experimental and control groups were treated with a transcutaneous electrical nerve stimulator and continuous passive motion. Muscle activity was measured with surface electromyography. Pain was measured with the visual analogue scale. The paired t-test was used to compare groups before and after the experiment. The independent t-test was used to assess the differences in the degree of change between the two groups before and after the experiment. [Results] Subjects of both the experimental group and control group showed significant differences in muscle activity and pain. However, as compared with the control group, there was significant differences in the muscle activity and pain in the experimental group. [Conclusion] These results indicate that combined exercise with slings and a Flexi-Bar is effective in improving muscle activity and decreasing pain in rotator cuff repair patients.

Key words: Combined exercise with a sling and Flexi-Bar, Muscle activity, Pain

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INTRODUCTION

The rotator cuff is formed by the convergence of the supraspinatus, infraspinatus, teres minor, and subscapularis muscles; therefore, rupture of the rotator cuff implies rupture of these four muscles^{1, 2)}. The rotator cuff suture is generally used for repair, and it maximizes the contact area between the bone and tendon, thereby creating normal spaces between anatomical structures³⁾. To provide an efficient rehabilitation program for patients with an impaired rotator cuff and to enable recovery from malfunction of the shoulder joint, management includes muscular strength and endurance management, pain reduction in the shoulders, improvement of the range of motion within which the shoulder joint can move as much as possible, and focusing on recovery of the ability that controls balance among stabilizing muscles^{4, 5)}. Among many other therapeutic methods for stabilizing the shoulders, sling exercise is a method that can cause an integrated effect on both sense and motion through performance of active movements on an uneven surface and slings attached to a moving rope⁶⁾. Moreover, it also has an effect on soft tissue release, increases joint range of motion, stabilizes muscular tissue, and enhances muscular strength^{7, 8)}. Rotator cuff repair patients need what they can do actively⁹⁾. The vibration stimuli typically used in training does not cause any particular side effect, and anyone can get used to it easily⁹⁾. An active vibration stimulus causes simultaneous contraction in stimulated muscle groups and can develop muscular ability and nerve control. In addition, it can restrict abnormal tension

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of muscle, thereby allowing patients with a muscular imbalance to adapt to it¹⁰⁻¹²). Vibration stimuli produced using a Flexi-Bar enhance muscular strength, coordination, and balance¹³). However, there is an insufficient amount of research on the effect of the Flexi-Bar exercise on patients with shoulder problems and on the combination of Flexi-Bar exercise with active vibration stimuli and stabilization exercise that uses a sling. Therefore, this study aimed to find out if complex exercise using slings and a Flexi-Bar has an effect on muscle activity and pain in patients after rotator cuff repair. In addition, it aimed to provide reasons for any observed effects and basic clinical data.

SUBJECTS AND METHODS

This study included 20 participants who were diagnosed with rupture of the rotator cuff and had undergone joint surgery in the past 6 weeks. The participants who understood the purpose of this study were assigned randomly into groups of 10 as the experimental group and the control group. Subjects who had undergone surgery for rupture of the rotator cuff or other indications and who were diagnosed with other conditions such as mental disease or other nerve disorders were excluded. All subjects provided written informed consent prior to participation in the study according to the ethical standards of the Declaration of Helsinki. The average age, weight, height, and body mass index (BMI) of the experimental group were 44.2 ± 5.4 years, 70.5 ± 10.2 kg, 168.9 ± 7.9 cm, and 24.6 ± 2.1 kg/m², respectively, and those of the control group were 44.1 ± 4.5 years, 64.6 ± 9.2 kg, 167.8 ± 7.5 cm, and 22.8 ± 1.9 kg/m², respectively (Table 1).

Both groups were treated with a transcutaneous electrical nerve stimulator (TENS) and continuous passive motion (CPM) for 40 minutes a day, 6 days a week, for 3 weeks. The experimental group was asked to perform the combined exercise using slings and Flexi-Bar. The sling exercise was conducted with the effect of gravity removed using slings. The sling exercise program consisted of the following movements: scapula setting conducted in a prone position with a sling on the affected arm, shoulder protraction and retraction conducted in a sitting position with a sling on both arms, shoulder flexion conducted in a side-lying position with the sling on the affected arm, shoulder abduction conducted in a supine position with a sling on the affected arm, and shoulder horizontal abduction and horizontal adduction conducted in a sitting position with a sling on the affected arm. The Flexi-Bar exercise was conducted in a sitting position while the effect of gravity was removed by flexing both shoulders to 90 degrees and strapping them into slings. The Flexi-Bar exercise program consisted of up-down oscillation exercise of the forearm conducted in pronation and supination positions and left-right oscillation exercise conducted in a neutral position. The experimental group conducted the exercise programs for 50 minutes a day, 3 days a week, for 3 weeks. Surface electromyography (EMG; BTS FREEEMG 300, BTS S. p. A., Milan, Italy) was used to measure muscle activity. We attached an electrode to the upper trapezius, lower trapezius, infraspinatus, and serratus anterior. The collected electromyography data were normalized to the percentage of reference voluntary contraction (%RVC) and further processed and expressed as the root mean square (RMS). To record the reference voluntary contraction (RVC) value of subjects, the subjects were asked to sit comfortably on a chair with their arms at their sides and to ensure that they sat with an even posture to enable correct measurement. For the voluntary contraction standard, the subjects were asked to sit on a chair with their elbows straight and shoulder joints curved at 90° for measurement.

The visual analogue scale (VAS) was used for pain measurement. The VAS is a 10 cm straight line scale marked with numbers indicating the degree of pain felt. The left-hand side of the scale signifies “no pain,” and the right-hand side signifies maximum pain. We measured the outcome in centimeters.

The collected data were statistically processed using IBM SPSS Statistics 22.0 (IBM Corp., Armonk, NY, USA) for Windows. Subjects’ overall characters were evaluated by descriptive statistics. The paired t-test was used to compare groups before and after the experiment. The independent t-test was used to assess the difference in the degree of change between the two groups before and after the experiment. The significance level was set to $\alpha=0.05$.

Table 1. General characteristics of the subjects

	EG (n=10)	CG (n=10)
Gender (male/female)	6/4	5/5
Age (years)	44.2 ± 5.4^a	44.1 ± 4.5
Weight (kg)	70.5 ± 10.2	64.6 ± 9.2
Height (cm)	168.9 ± 7.9	167.8 ± 7.5
BMI (kg/m ²)	24.6 ± 2.1	22.8 ± 1.9

^aMean \pm SD.

EG: experimental group; CG: control group

RESULTS

The changes in muscle activity and pain are shown in Table 2. The subjects in both the experimental group and control group showed significant differences in pain and muscle activity of the upper trapezius, lower trapezius, infraspinatus, and serratus anterior ($p < 0.05$). However, the differences in pain and muscle activity of the upper trapezius, lower trapezius, infraspinatus, and serratus anterior of the experimental group appeared to be significant as compared with those of the control group ($p < 0.05$).

DISCUSSION

The purpose of this research was to determine the effect of combined exercise with slings and Flexi-Bar on muscle activity and pain in rotator cuff repair patients. The subjects in both the experimental group and control group showed a significant difference in muscle activity of the upper trapezius, lower trapezius, infraspinatus, and serratus anterior. However, the upper trapezius of the experimental group showed significantly reduced muscle activity compared with the control group, whereas the muscle activity of the lower trapezius, infraspinatus, and serratus anterior increased significantly in the experimental group compared with the control group. In a pilot study, patients with shoulder problems had lower muscle activity in stabilizing muscles such as the serratus anterior or middle and lower trapezius and an over-activated upper trapezius. This caused an imbalance in the shoulder muscles and even caused pain¹⁴. According to a study by Hong et al.¹⁵, the torque of motion in shoulder joints significantly increased after vibrations were applied their subjects via a vibration platform. According to a study by Kirkesola¹⁶, when a sling was used for vibration exercise, it was found that incorrect neuromuscular control could be corrected, thereby reducing muscle imbalance. The present study was consistent with the abovementioned pilot study, and it was found that combined exercise using both slings and a Flexi-Bar has a positive effect on the activation of muscle activity.

The subjects of both the experimental group and control group showed a significant difference in pain. In addition, shoulder pain in the experimental group was significantly reduced compared with that in the control group. In a study by Bakhtiary et al.¹⁷, it was found that shoulder pain significantly decreased as a result of vibration exercise using a vibrator. In a study by Jung¹⁸, it was found that pain was significantly reduced after patients with shoulder problems performed shoulder-stabilizing exercise. Burkhart et al.¹⁹ found that middle-aged women felt less pain as a result of performing sling exercise. The results of prior research and this study are consistent. Combined exercise with slings and a Flexi-Bar improved muscle activity and pain in rotator cuff repair patients.

This research has a limitation with respect to generalization of the findings to all rotator cuff repair patients, as it was conducted on a small group. Furthermore, the experimental period was short due to the period of hospitalization of the patients. In addition, follow-up was not performed; therefore, the duration of the effect is unknown.

In conclusion, combined exercise using slings and a Flexi-Bar is effective for improving muscular imbalance and decreasing pain in rehabilitation after rotator cuff repair. Therefore, combined exercise using slings and Flexi-Bars will offer clinical guidelines for early return of patients to daily life after rotator cuff repair and will be useful for many patients.

Table 2. Comparison of the results of muscle activity and pain between the experimental and control groups

	Group	Pre	Post	D-value
Upper trapezius	EG	1,261.1 ± 88.6 ^a	984.5 ± 79.7*	-276.5 ± 44.8 [#]
	CG	1,261.2 ± 77.3	1,177.3 ± 91.3*	-83.8 ± 20.8
Lower trapezius	EG	433.3 ± 30.1	581.2 ± 54.8*	147.9 ± 41.7 [#]
	CG	412.0 ± 50.5	451.2 ± 51.0*	39.2 ± 16.1
Infraspinatus	EG	440.3 ± 28.8	581.6 ± 40.5*	141.2 ± 41.7 [#]
	CG	426.7 ± 48.0	454.9 ± 51.9*	28.1 ± 15.5
Serratus anterior	EG	333.1 ± 22.6	520.4 ± 50.5*	187.3 ± 37.5 [#]
	CG	325.5 ± 37.1	359.8 ± 49.9*	34.2 ± 23.7
Pain	EG	7.1 ± 1.2	2.7 ± 0.6*	-4.4 ± 0.7 [#]
	CG	7.4 ± 0.7	4.4 ± 0.9*	-3.0 ± 0.6

^aMean ± SD.

* $p < 0.05$ (paired t-test), [#] $p < 0.05$ (independent t-test).

D-value: difference value; EG: experimental group; CG: control group

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