

Effect of Motor Control Training with Strengthening Exercises on Pain and Muscle Strength of Patients with Shoulder Impingement Syndrome



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Purpose: The purpose of this study was to investigate the effect of movement training based on motor control theory on pain and average power of muscles in patients with shoulder impingement syndrome and to develop more effective training methods.

Methods: We studied 35 patients with shoulder impingement syndrome. Patients were randomly assigned to an experimental group or a control group according to the intervention. The therapeutic modalities such as superficial heat, deep heat, and electronic stimulus, and motor control training with strengthening exercises were applied to the experimental group and therapeutic modalities only were applied to the control group. All interventions were done 3 times a week for 4 weeks. Before the intervention and again after the 4 weeks, we measured pain utilizing a visual analog scale. We measured average power using isokinetic equipment.

Results: After application of the intervention, pain significantly decreased in both the experimental group and the control group. There was a significant difference between the extent of the decrease between experimental and control groups. After the intervention, the average power between the two groups were significant at an angle of 60°/sec and 180°/sec for external rotator and internal rotator muscles. They also showed significant improvement in all variables post-intervention compared to pre-intervention.

Conclusion: This study indicates that there is an effect in giving appropriate motor control training to patients with shoulder impingement syndrome. It is assumed that there will be a need for more surveys on various variables for motor control training from now on.

Keywords: Motor control, Shoulder impingement syndrome, Average power

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1. Introduction

The shoulder is the joint where diseases of the musculoskeletal system related to deficiency of movement can easily occur.^{1,2} In particular, shoulder impingement syndrome is a disease of the musculoskeletal system that can often occur in the shoulder joints and generates abnormal movements.³ Shoulder impingement syndrome is a disease that happens when there is repetitive mechanical pressure in the construction in space that is under the coracoacromial arch during movement of the arm upward.⁴ Due to various reasons, there occur changes in the degree of activity of the muscles around the shoulder. During the period when one

moves the arms, there also occur kinematic problems in the scapula, clavicle and humerus, resulting in the impingement of the construction object in the space under the coracoacromial arch.⁵ Because of that, there is pain when the arm is moved upwards. There also occurs limitation of the range of motion and muscle weakness.⁶

In around half of patients with shoulder impingement syndrome, there occurs changed movement compared to normal adults when the patient does stretching actions in the frontal plane.⁷ During the movement of stretching, more rotation of the trunk and more elevation of the clavicle occur.⁷ This type of movement is to compensate for the deficient movement of the

arms such as the displacement of the humerus' upward during the moving of the arm upward.⁸ Through the rotation of the trunk, it protects the minimizing movement of the space under the peak.⁹ And by moving the clavicle upwards, the purposed stretching action is implemented.⁹ It is said that patients with shoulder impingement syndrome can have normal stretching functions by doing movement training.¹⁰ In previous studies, it was reported that movement training was effective for patients with shoulder impingement syndrome.¹¹⁻¹² Movement training supplies methods such as instruction, demonstration and extrinsic feedback, and is based on the theory of motor control.¹³⁻¹⁵ So, movement training is similar to motor control training. Motor control training is the process of adjusting for inappropriate movement. It is training that leads to stability of movement by learning normal movement through repetitive practice. In the shoulder joint, motor control training applies stepwise feedback depending on the degree of dysfunction by learning normal movement such as intentional and goal-oriented movement.¹⁶ It promotes motor learning by supplying instruction, demonstration and extrinsic feedback during motor control training.¹³⁻¹⁵ The reorganization of the brain that occurs in line with the deficiency of the movement due to the disease of the musculoskeletal system is the evidence for this intervention.¹⁷⁻¹⁹ Inappropriate movements that persist in patients with musculoskeletal system disease brings cortical reorganization and generates changes in the organization of the cerebral cortex.²⁰

Motor control training based on motor control theory reorganizes the cerebral cortex and lets the appropriate motor strategy be implemented.²¹ It has been proved that this kind of training not only leads to the reorganization of the cerebrum of a healthy person, but also enhances the movement implementing capacity in patients with diseases of the musculoskeletal system.²²⁻²⁴ It also restores normal movement of the shoulder joints without generating pain, and enhances dynamic stability for patients with shoulder impingement syndrome.²⁵

Accordingly, in this research we intend to investigate the

effect of motor control training on pain and average power of muscles in patients with shoulder impingement syndrome and develop effective training methods.

II. Methods

1. Subjects

This study investigated 35 patients who were outpatients in hospital C in Gyeonggi-do. The selection criteria were that we selected persons who were diagnosed as having shoulder impingement syndrome while being treated by orthopedic professionals and has at least one of the following symptoms: pain during flexion and abduction, a positive response in the Neer impingement test or in the Hawkins-Kennedy impingement test, and pain in the empty can test or pain on external rotation and abduction. We have excluded those with fractures, past surgery in the shoulder joint areas, those with pains in the shoulder due to problems in the neck bone and those with serious communication problems. We asked for the agreement of all participants in this study after we explained the purpose of the study. The characteristics of the participants in this study were as follows (Table 1).

2. Procedures

The subjects for this study were assigned to the experimental group or the control group, randomly, according to the intervention. For the experimental group, we implemented therapeutic modalities such as superficial heat, deep heat and electronic stimulus and motor control training with strengthening exercises. For the control group, we applied only the therapeutic modalities. All the interventions were applied 3 times per week for 4 weeks and pain and average power were measured before and after the 4 weeks.

1) Motor control training

Motor control training is composed of 6 steps that regulated the shoulder joints in the frontal, sagittal and transverse planes.

Table 1. Subject characteristics

Group (n=35)	Sex (male/female)	Side of Injury (R/L)	Age (years)	Height (cm)	Weight (kg)
Experimental (n=17)	6/11	11/6	49.9±5.5	161.7±7.7	59.1±8.6
Control (n=18)	6/12	14/4	48.3±4.3	162.0±7.6	62.7±8.5

Movement of the arm is implemented as passive movement, active-assist movement, active movement without resistance, and resistance movement where an external resistance was applied. During motor control training, the training intensity was regulated by applying feedback²⁴ (Tables 2, 3). The training for each step was performed such that 10 times was one set and 3 sets were done. When the patient could control movement in all directions over the full range of motion, we moved on to the next step. A physical therapist explained the program to the subjects before the training started. All training was done under the supervision, instruction and feedback of the physical therapist in a range where there was no pain.

Table 2. Manual feedback was given according to scapular dyskinesis

Types of dyskinesis	Manual feedback
Decrease of the scapula lateral rotation	Guidance of lateral rotation with lateral pressure placed on the inferior angle of the scapula
Tilt of the scapula inferior angle	Restriction of the tilt with anterior pressure placed on the inferior angle of the scapula
Elevation of the superior border of the Scapula	Restriction of the scapular elevation with inferior pressure placed on the acromion
Tilt of the medial scapula border	Restriction of the tilt with anterior pressure placed on the medial border of the scapula

2) Strengthening exercises

Strengthening exercises included: external rotation, internal rotation, scaption, chair press, push-up plus, press-up, rows, upright rows, and lower trapezius exercises. Each exercise was done in 3 sets of 10 repetitions each²⁵ (Table 4). We set 70% of maximum strength as the intensity of the exercises; that was assessed according to the movement plane, the range of motion, the repetitions, the velocity, and the resistance.

A 10-min rest period was provided between motor control training and strengthening exercises. All exercises were performed pain free.²⁰⁻²¹ Before the exercise, the physical therapist educated the subjects about the exercise programs using illustrations.

3. Measures

1) Visual analog scale (VAS)

Degree of pain was assessed using a visual analog scale.²⁶ The visual analog scale displays the degree of pain that the patient is feeling on a scale that does not have gradations. The starting point of the line is 0 and the ending point is 10. After letting the patient mark the level of pain experienced, the researcher measured the distance from the starting point and converted it into a score. A state of no pain was 0 and of unbearable pain was 10.

2) Average power.

Average power was measured with isokinetic equipment (Cybex 770, USA). Measurements of average power using isokinetic equipment such as that from Cybex have high reliability because they can accurately measure the muscle power used in constant

Table 3. Phase for retraining the shoulder control according to scapular dyskinesis

Phases	Steps for retraining the shoulder control			
	1	2	3	4
1*	Passive elevation	Final position actively kept for 5 sec	Active return with manual feedback if needed	Verbal feedback
2*	Active assisted elevation	Final position actively kept for 5 sec	Active return with manual feedback if needed	Verbal feedback
3*	Active elevation with manual feedback if needed	Final position actively kept for 5 sec	Active return with manual feedback if needed	Verbal feedback
4*	Phase 3, but without manual feedback			
5	Phase 4, but without visual feedback.			
6	Phase 5, but with the elevation performed faster, and then with a load.			

* In front of a mirror (visual feedback)

Table 4. Muscle strengthening exercise

Exercise	Description
External rotation & Internal rotation	Secure the elastic band at the waist level. Hold the elbow at 90° with the arm at the side. Pull the hand away (external rotation) from the body. Pull the hand across (internal rotation) the body.
Scaption	Hold the arm 30° forward, thumb up or down, and raise the arm. May add resistance. This exercise should be done only if there is no pain.
Chair press	While seated, press up on the chair to lift the body off the chair. Try to keep the spine straight
Push-up plus	Do a push-up (either on your hands or forearms) and then really push to bring your spine to the ceiling.
Press-up	Lie on the back, elbows locked straight, weights in hands. Move your arm up toward the ceiling as far as possible.
Rows	Seated or standing, bend your elbows and pull the elastic cord back. Try to pinch your shoulder blades behind you.
Upright row	Do one arm at a time. While standing, lean over a table and bend at the waist. Pull the hand weight back with pulling the shoulder blade back.
Low trapezius	Stand upright. Grasp the elastic bands. Keep your elbows straight and pull. Try to reach behind you.

angular velocity and range of motion. The average power of the muscle represents the amount of work that can be generated as the ability of muscle to generate the energy.²⁷ For external and internal rotator muscles, we measured it 5 times at an angle of 60°/sec and another 5 times at 180°/sec and recorded the values. During the measurement, we had 5 minute intervals during each velocity angle. In order for the subjects to exert average power, subjects practiced the movement 3 times with the external rotator and internal rotator.

4. Statistical analysis

We used a paired T-test in order to analyze differences in pain and in average power after 4 weeks. We made comparisons to pretest values for each group. We used an independent T-test to compare differences in pain and average power between experimental and control groups after 4 weeks. The statistical significant level was set at $p < 0.05$ for all data.

Table 5. The difference between before and after in experimental and control group, experimental and control group on VAS and muscle average power in postintervention

Measures	Values				Change Values	
	Experimental group (n=17)		Control group (n=18)		Experimental(n=17)	Control(n=18)
	Pretest	Posttest	Pretest	Posttest	Post-Pre	Post-Pre
VAS (point)	4.05±1.48	0.79±0.65 [†]	4.24±1.06	1.86±0.62 [†]	3.27±1.30*	2.38±0.98
ERAP 60°/sec watts	9.74±3.57	11.97±3.59 [†]	8.63±3.36	9.30±3.38	2.24±1.76*	0.67±1.69
ERAP 180°/sec watts	14.69±7.16	17.59±4.75 [†]	12.34±5.69	13.14±4.63	2.89±2.93*	0.80±1.93
IRAP 60°/sec watts	15.71±5.19	17.70±4.75 [†]	15.94±4.55	15.76±4.44	1.99±1.11 [†]	0.19±0.40
IRAP 180°/sec watts	24.01±9.55	25.65±8.56 [†]	21.88±6.88	22.01±6.85	1.65±1.46*	0.14±0.54

* $p < 0.01$

[†] $p < 0.001$

VAS: Visual analog scale

ERAP: Average power of external rotator

IRAP: Average power of internal rotator

III. Result

1. Change in visual analog scale score

There were significant decreases after 4 weeks in the experimental and controls. There were significant differences between the experimental group and the control group after 4 weeks (Table 5).

2. Change in average power

After 4 weeks, there were significant changes on average power of the external rotator and on average power of the internal rotator in experimental group, but there were no significant increases in all variables in the control group. After 4 weeks, there were significant differences in all variables between the two groups (Table 5).

IV. Discussion

In this study, we investigated the effects of motor control training with strengthening exercises on pain and average power in patients with shoulder impingement syndrome. In both groups – the control group with only therapeutic modalities and the experimental group with therapeutic modalities and motor control training with strengthening exercises – there was significant improvement in both pain and average power. After the intervention, there were significant differences in pain and the average power between the two groups.

The results of this study were similar to other studies. The application of the exercise program with manual therapy for the 30 patients with shoulder impingement syndrome showed that pain decreased in both groups, one with only the exercise program and the other with the exercise program with manual therapy. It was reported that for the group that had the manual therapy also, there was a significant decrease.² When Roy *et al.*⁷ applied motor control training and muscle strength exercises for 4 weeks in patients with shoulder impingement syndrome, the pain significantly decreased. Three of the subjects recovered much of the strength of the shoulder abductor; 4 recovered strength of the external rotator, but the amount was not significant. They reported that the reason why we had this kind of result is because we have emphasized both interventions, and the reason why didn't occur significantly differences is because

the duration of training was too short to improve muscle strength by implementing muscle strengthening Lombardi *et al.*²⁸ reported that application of a gradual resistance exercise program for the decrease of pain, increased of muscle strength, and enhanced function and quality of life. The program was done 2 times per week for 4 weeks. And Muscle strength of the external and internal rotators, and total work also increased. Another study reported that muscle strength exercises in patients with shoulder impingement syndrome for 6 weeks increased the muscle strength of rotator and abductor.²⁹ But they said that for patients with shoulder impingement syndrome, rather than doing an intervention only for the enhancement of muscle strength, intervention for improving the function and preventing the recurrence of pain should be used. For this, we have to establish proper exercise strategies and implement motor control training and muscle strengthening.

But, compared to previous studies that had applied only muscle strengthening, this study showed a little difference in the applied time of the intervention. The duration of the intervention for this study was 4 weeks whereas the duration for previous studies was 6 to 8 weeks. Nonetheless, in the pain and muscle strength, there are significant differences. It seems to be because motor control training providing feedback about the movement of shoulder lets that subjects perceived the movement and control movement of the shoulder appropriately and decreased the imbalance of the muscles. According to the steps for learning by Fitts & Posner,³⁰ the subjects should go through the perception step which is the first step. In this step, perception activity is needed for the decision to select the appropriate process. Through this step, patients with shoulder impingement syndrome can find what type of problems they should solve and what they should do to improve adjustment of their shoulders. But, the actual implementation may be different from what they perceive about the movement. Through this perception activity, the speed of the movement can decrease. So, in various studies, they suggested a few methods to apply the appropriate training as the most effective motor learning step. In the first method, to improve the ability to detect intrinsic errors, education about the shoulder's anatomy should be implemented before training. And the subjects should compare movements visually such as verifying the movement of the impaired or non-impaired shoulders through a mirror. Finally, they should judge whether the movement is normal for themselves before receiving verbal

feedback from the physical therapists. The learning effect can be magnified through these methods. In this study, we used the above method to implement the intervention. It seems that pain and average power improved using this principle.

In this study, we investigated the effect of motor control training with strengthening exercises in the patients with shoulder impingement syndrome on their pain and on average power of muscle. There was significant improvement in pain and average power. After 4 weeks, there was a significant difference in the pain and the average power between the experimental and control groups. Through the results of this study, we know that motor control training is effective for patients with shoulder impingement syndrome. In particular, they need effective training lessons for the adequate motor control. There is now a need for more studies on various variables in the effect of motor control training, and studies will have to be implemented in a way that various appropriate protocols can be applied according to the disease and the damaged area.

Author Contributions

Research design: Bae, YH

Acquisition of data: Bae, YH

Analysis and interpretation of data: Bae, YH

Drafting of the manuscript: Lee, GC

Research supervision: Lee, GC

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