

The Effects of Stretching and Stabilization Exercise on the Improvement of Spastic Shoulder Function in Hemiplegic Patients

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Abstract. [Purpose] This study investigated the effects of stretching and joint stabilization exercises applied to spastic shoulder joints on improving shoulder dysfunction in hemiplegic patients. [Subjects and Methods] Hemiplegic patients were classified into three groups: one group received 30 min of traditional exercise therapy for the spastic shoulder joint; one group received 30 min stretching; and one group received 15 min of stretching and 15 min of joint stabilization exercises. The exercises were performed once a day, five times per week for eight weeks. Changes in the pathologic thickness of tendons and recovery of shoulder function were compared among the three groups. Differences among the three groups before the experiment, at four weeks, and at eight weeks were analyzed using repeated measures ANOVA. [Results] The stretching and joint stabilization exercise therapy group showed greater improvement in shoulder function than the traditional exercise therapy group and the stretching only group. This group also showed greater decreases in the pathologic thickness of tendons, than the other groups. [Conclusion] This study demonstrated that an exercise therapy program that combined stretching and joint stabilization exercise was more effective than other exercises for improvement of spastic shoulder joint dysfunction in hemiplegic patients.

Key words: Spasticity shoulder, Joint stabilization, Stretching

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INTRODUCTION

Shoulder pain in hemiplegic patients has high correlations with spasticity, sensory changes, and severe subluxation of the shoulder¹⁾.

Spasticity is a general symptom in most poststroke hemiplegic patients. Increased muscle tone causes shoulder pain caused by traction of the tendon, which is a muscle-adhered region resulting from the shortening and spasticity of the periarticular soft tissues²⁾.

In previous studies, investigations of the characteristics of the tendon with diagnostic ultrasonography have generally evaluated subject age and disuse, motor, and mechanical characteristics of tendons under maximum muscle contraction^{3, 4)}. Recent studies have also found that the thickness, length, biomechanical characteristics, stiffness, and hysteresis of the affected tendon were increased compared with

those of the unaffected tendon in stroke patients⁵⁾. Fixed positions caused by immobilization of the soft tissues around the muscles and joints can lead to permanent structural changes, such as decreased range of motion and stiffness⁶⁾.

The findings of previous studies^{7–10)} suggested that shoulder dysfunctions in hemiplegic patients are caused by complex factors, including spasticity, capsulitis, and tendinitis. These studies also showed that management of spasticity is critical for improvement of function. Therefore, stretching and joint stabilization exercises are an important therapeutic approach for improving shoulder function. This study was conducted with the expectation that this approach would decrease the muscle tone as a result of the change in length of the spastic muscle, improve the activity of the antagonistic muscle, and improve the activity of the tendon.

SUBJECTS AND METHODS

All participants provided informed consent prior to participation in this study. The experimental protocol was approved based on the ethical standards of the Declaration of Helsinki.

The subjects of this study were selected from patients who had been diagnosed with poststroke hemiplegia and

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hospitalized in a hospital specializing in rehabilitation. Forty-five patients who understood the details of this study consented to participate. The inclusion criteria were as follows: Patients who were six months or more but less than two years after the onset of stroke, patients in which spasticity of biceps brachii was in stages 1–3 on the modified Ashworth scale (MAS), and patients who had no shoulder pain six months before onset. The exclusion criteria were as follows: patients who had a severe injury of the rotator cuff, patients who had undergone shoulder surgery after a shoulder injury, and patients considered unable to participate in this study because of psychiatric problems.

This study was conducted by applying eight weeks of exercise therapy to the participants, who were selected based on the above criteria.

The medical records and physical function test sheets of all hospitalized patients were examined to select subjects who satisfied the criteria for this study. The 45 patients that consented to participate in this study were randomized into three groups. One discharged patient left the normal development therapy group, two discharged patients left the stretching exercise therapy group, and one discharged patient left the stretching and joint stabilization exercise therapy group. Consequently, 41 patients participated throughout this study, and the data analysis was performed using the data of these 41 patients.

Every subject received normal development therapy, for improvement of physical functions, one hour and 30 min of exercise therapy three times a week, and one hour of occupational therapy five times a week, in addition to the 30-min exercise therapy programs used in this study.

In the preliminary investigation of these exercise therapy groups, sonography was conducted to measure the thickness of the biceps brachii tendons of both the affected and unaffected sides and shoulder functions. The evaluations were performed for all subjects at four weeks and then at eight weeks when the exercise therapy intervention was completed.

Normal development therapy, stretching exercise therapy, stretching and joint stabilization exercise therapy, and evaluations were performed by physical therapists with at least three years of clinical experience. The authors of this paper directed and supervised the consistency of the therapy programs and their evaluations.

Concerning the neurophysiology approach, the normal development therapy program applied in this study was neurodevelopment treatment according to motor development theory and motor learning theory¹¹.

The stretching program applied here was a revised version of that used in a previous study¹². First, maximum shoulder external rotation at 45° abduction was performed in the supine position and gradually extended as long as there was no pain. Then, stretching was performed at 90° of the shoulder in a sitting position and gradually extended as long as there was no pain. Finally, the subjects reached toward the ground with their palms with shoulder and elbow extension in a sitting position and gradually extended their reach as long as there was no pain.

Joint stabilization exercise used in a previous study was

revised¹³ to affect the stability and mobility of the rotator cuff, scapula, and glenohumeral joint, which are involved in stabilization of the shoulder joint. Furthermore, an elastic band was used for resistance to prevent pain and fatigue, the assistance of the therapist was minimized, and a 10-second hold time was used for each position. For the joint stabilization exercise, the subjects started in a shoulder neutral position, holding the band, with shoulder abduction of 0–60° on the scapular plane and elbow flexion of 90°. Next, they punched forward from the shoulder neutral position with shoulder flexion of 0–60° on the sagittal plane and elbow flexion of 90°. They then performed adduction of the scapulas with elbow flexion of 90° and the shoulders in neutral rotation with their arms by their sides. Finally, they performed shoulder external rotation with upper limb abduction of 45°, elbow flexion of 90°, internal rotation of 30°, and external rotation of 30°.

The thicknesses of the long head tendons of the biceps brachii on the affected and unaffected sides were measured by one physiatrist using diagnostic ultrasonography equipment (LOGIQ 400CL, GE Healthcare, Wauwatosa, WI, USA). For sonographic measurement, the cross-sectional image of the biceps groove was obtained in pronation of the forearm at 0° with elbow flexion of 90°, and the thicknesses were measured at the origins of the affected tendons¹⁴. For the normal tendons, thin fiber aggregates were arranged in parallel, and cutting or deformation of their shape was considered an abnormality¹⁵. The thickness of the long head tendons of the biceps brachii with scar tissue was 8 mm or greater, which is considered a symptom of tendinitis¹⁶.

The measurement of functional movement of the shoulder joint used the motor assessment scale for stroke, which was used in a previous study¹⁷. For single-function measurement of the shoulder joint, measurement item no. 6 was used. The scores ranged from 0 to 6; the closer to the score was to 6, the closer the function was to a normal state.

PASW 18.0 for Windows was used for all statistical analyses performed in this study. The demographic characteristics of the subjects were analyzed by the independent t-test and chi-squared test. The Kolmogorov-Smirnov test was used to test the normality of the variables. The changes over time were compared among the three groups before the experiment and at four and eight weeks after the experiment. The differences in the changes among the three groups before the experiment, at four weeks, and at eight weeks were analyzed through repeated measures ANOVA. The Bonferroni method was used to determine differences between prior to the experiment and at four weeks, between four and eight weeks, and between prior to the experiment and at eight weeks. The differences in changes by period between the exercise therapy groups were analyzed by ANCOVA, and the preliminary measurements were used as covariate values. The level of statistical significance was set to $p < 0.05$ for all data.

RESULTS

The general characteristics of the subjects and the results of homogeneity testing are shown in Table 1. The thickness-

es of the affected tendons are shown in Table 2. In the case of the normal development therapy (group 1), the thickness of the affected tendon was 7.61 ± 0.7 mm before the experiment, 7.28 ± 0.57 mm at four weeks, and 5.19 ± 0.92 mm at 8 weeks. In the repeated measurements, the thickness of the affected tendon showed a significant decrease over time ($p < 0.05$). In the case of the stretching exercise therapy (group 2), the thickness of the affected tendon was 7.57 ± 0.85 mm before the experiment, 7.29 ± 0.84 mm at four weeks, and 5.48 ± 0.49 mm at eight weeks. In the repeated measurements, the thickness of the affected tendon showed a significant decrease over time ($p < 0.05$). In the case of the stretching and joint stabilization exercise therapy (group 3), the thickness of the affected tendon was 7.38 ± 0.87 mm before the experiment, 7.08 ± 0.74 mm at four weeks, and 5.63 ± 0.57 mm at eight weeks. In the repeated measurements, the thickness of the affected tendon showed a significant decrease over time ($p < 0.05$).

The post-hoc comparison results were week 0:week 4 ($p < 0.05$), week 0–week 8 ($p < 0.05$), and week 4–week 8 ($p < 0.05$) for all three groups, and the thickness of the affected tendon significantly decreased in week 0–week 4, week 0–week 8, and week 4–week 8. The results of comparison of the changes in thickness among the three groups showed no significant difference between group 1 and group 2 ($p = 0.84$). There was a significantly greater decrease in thickness in group 3 compared with group 1 ($p < 0.05$), and there was a significantly greater decrease in thickness in group 3 compared with group 2 ($p < 0.05$).

The results for motor function of the arm are shown in Table 3. In the case of the normal development therapy (group 1), motor function of the arm was scored as 1.64 ± 0.63 before the experiment, 2.07 ± 0.61 at four weeks, and 2.50 ± 0.51 at 8 weeks. In the repeated measurements, motor function of the arm showed a significant increase over time ($p < 0.05$). In the case of the stretching exercise therapy (group 2), motor function of the arm was scored as 1.54 ± 0.66 before the experiment, 2.08 ± 0.49 at four weeks, and 2.85 ± 0.55 at eight weeks. In the repeated measurements, motor function of the arm showed a significant increase over time ($p < 0.05$). In the case of the stretching and joint stabilization exercise therapy (group 3), motor function of the arm was scored as 1.50 ± 0.51 before the experiment, 2.00 ± 0.55 at four weeks, and 3.36 ± 0.84 at eight weeks. In the repeated measurements, motor function of the arm showed a significant increase over time ($p < 0.05$).

The post-hoc comparison results were week 0–week 4 ($p < 0.05$), week 0–week 8 ($p < 0.05$), and week 4–week 8 ($p < 0.05$) for all three groups, and the motor function of arm significantly increased in week 0–week 4, week 0–week 8, and week 4–week 8. The results of the comparison of changes in function of the arm among the three groups showed no significant difference between group 1 and group 2 ($p = 0.151$). There was a significantly greater increase in function of the arm in group 3 compared with group 1 ($p < 0.05$), and there was a significantly greater increase in function of the arm in group 3 compared with group 2 ($p < 0.05$).

Table 1. General characteristics of the subjects (n=41)

Group Variable	Group 1 (n=14)	Group 2 (n=13)	Group 3 (n=14)
Age (years)	58.8±7.4	57.8±8.1	58.7±6.6
Height (cm)	164.5±7.5	165.9±7.5	165.5±7.8
Weight (kg)	60.8±10.5	62.3±10.7	62.7±11.4
Onset (months)	11.71±3.62	11.54±3.07	11.36±3.05
Spasticity (grade)	2.21±0.32	2.26±0.38	2.21±0.54

* $p < 0.05$

Table 2. Comparison of AUS between the three groups (n=41)

Group Variable	1 (n=14)	2 (n=13)	3 (n=14)
	Mean±SD	Mean±SD	Mean±SD
0 week	7.61±0.70	7.57±0.85	7.38±0.87
4 weeks	7.28±0.57	7.29±0.84	7.08±0.74
8 weeks	5.19±0.92	5.48±0.49	5.63±0.57
Change	2.42±0.22	2.09±0.36	2.75±0.30
	*	*	*

* $p < 0.05$; AUS: Affected side UltraSonography of the biceps brachii long head tendon; Change from 0 week to 8 weeks.

Table 3. Comparison of motor assessment scale between the three groups (n=41)

Group Variable	1 (n=14)	2 (n=13)	3 (n=14)
	Mean ± SD	Mean ± SD	Mean ± SD
0 weeks	1.64 ± 0.63	1.54 ± 0.66	1.50 ± 0.51
4 weeks	2.07 ± 0.61	2.08 ± 0.49	2.00 ± 0.55
8 weeks	2.50 ± 0.51	2.85 ± 0.55	3.36 ± 0.84
Change	0.86 ± 0.12	1.31 ± 0.11	1.86 ± 0.33
	*	*	*

* $p < 0.05$; MAS: Motor assessment scale; Change from 0 weeks to 8 weeks.

DISCUSSION

Stretching and joint stabilization exercise therapy was applied to the spastic shoulder joint to investigate changes in spastic muscle length, improvement in the coordination of shoulder muscles, and tendon thickness. The aim of the study was to demonstrate that stretching and joint stabilization exercise therapy could be an important therapeutic approach for the improvement of shoulder function in hemiplegic patients.

It was previously reported that the degraded function of the upper limb in hemiplegic patients had significant correlations with the decrease in proprioceptors, contracture of muscles, subluxation of the shoulder, increase in shoulder pain, and peripheral tissues (about 85%) of the shoulder joint that showed lesions under ultrasonography¹⁴.

Many previous studies have evaluated lesions of the shoulder joint in hemiplegic patients by ultrasonography. Ultrasonographic evaluation of the shoulder joints in post-stroke hemiplegic patients revealed lesions in the periph-

eral tissues of shoulder joints in 48 of 64 patients (75%). Similar lesions were found in the long head tendon of the biceps brachii (64.8%) and in the supraspinatus tendon¹⁸. An ultrasonographic evaluation of lesions for 84 hemiplegic patients showed that 62.2% of the patients had lesions in the affected tendon, and the most frequent lesions were tendinitis of the long head tendon of the biceps brachii and tendinitis of the supraspinatus¹⁹.

In the present study, ultrasonographic evaluation of the shoulder joints in poststroke hemiplegic patients also showed lesions in the long head tendon of the biceps brachii. The thickness of the affected tendon was 36% greater than that on the unaffected side, which was caused by the formation of scar tissue. This finding aligns with a previous study showing that exercises and activities were important for reinforcement of the motility of shoulder muscles and increase of muscle length¹⁴. In another study on spasticity accompanied by shoulder pain, however, application of exercise consisting of passive joint stretching further increased the contracture of the shoulder joint and shoulder pain because of the reflective position and protection against muscle spasm. Accurate application and special care were required in the stretching exercise²⁰.

As shown by many previous studies, the spasticity of muscles after hemiplegia changes the characteristics of muscle fibers, causes dysfunction of joint movement, and aggravates the actions caused by neurologic injuries²¹.

Studies on shoulder dysfunction in hemiplegic patients have emphasized the importance of an exercise program for shoulder stability^{22, 23}. The increase in stability and the decrease in spasticity of shoulder dysfunction are considered important because of their effects on stabilization of the shoulder joint. Scapula stabilization of the shoulder joint and muscle strengthening exercises for the scapulohumeral external rotation muscle over six weeks in patients improved scapulohumeral rhythm²⁴. A previous study on stretching reported that 30 min of static stretching of immobilized and shortened muscles of mice improved the mobility of sarcomeres²⁵. Application of 30 min of static stretching per day for four weeks by hemiplegic patients significantly prevented contracture of joints¹². A similar study claimed that at least 30 min of stretching was required to prevent contracture of joints and muscles in hemiplegic patients²⁶.

Although previous studies found differences regarding stretching application time, they commonly stressed the importance of stretching for the prevention of joint contracture and the recovery of shoulder joint function in hemiplegic patients. In particular, periarticular muscle strengthening exercise is needed to improve shoulder joint function in hemiplegic patients because the humerus head and scapula movements cannot resist gravity, generate incorrect mechanisms, and cause injuries of the periarticular soft tissue, neurologic pain, and dysfunction²⁷.

The results of this study showed that the combined exercise therapy program of stretching and joint stabilization exercises for spastic shoulder joint dysfunction in poststroke hemiplegic patients reversed the pathological changes in tendons and improved shoulder function.

There are many causes of shoulder dysfunction in post-

stroke hemiplegic patients and many therapeutic approaches to them, but stretching and joint stabilization exercises are indispensable to an exercise therapy program. The results of this study could provide reference data about exercise therapy intervention. Extending previous studies of other causes of shoulder dysfunction, future studies will develop the results of this study in a clinical setting.

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