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博士論文

The effects of Neuro-Muscular Electrical Stimulation (NMES) on shoulder subluxation in
flaccid hemiplegic patients.

(脳卒中弛緩性片麻痺患者の肩関節亜脱臼に対する電気刺激治療の効果)

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The effects of Neuro-Muscular Electrical Stimulation (NMES) on shoulder subluxation in flaccid hemiplegic patients.

Koji Shomoto

Abstract

We examined the effects of Neuro-Muscular Electrical Stimulation (NMES) on upper extremity function of flaccid hemiplegic patients using a randomized controlled trial with cross-over design. In this study, total of 44 patients with hemiplegia were selected. The experimental group received conventional therapy and NMES for 6 - 7 weeks. After finishing this session, 8 patients were treated by conventional therapy only, withdrawing the NMES. The control group received conventional therapy only. After finishing the session, 5 patients in the control group were given additional NMES treatments. Subjects received the NMES treatments a total of 5 hours per day, 5 days per week. After finishing 6 to 7 weeks of treatment, there were no significant differences between the groups in either motor function or muscle tone ($p>0.74$). But there were significant differences in ROM ($p<0.0001$), brachial circumference ($p<0.0001$) and subluxation ($p<0.0001$). The control group demonstrated a loss of passive ROM progressively over the 6 - 7 weeks, but the experimental group maintained their ROM, except for two patients with severe asomatognosia and unilateral spatial neglect. All patients in the experimental group showed a significant subluxation of the shoulder after the withdrawal of NMES. Five patients in the control group revealed a significant improvement in the subluxation of the shoulder ($p<0.05$) after starting the NMES treatment. It is suggested that the NMES treatment can prevent subluxation of the affected shoulder, except for those with severe asomatognosia and unilateral spatial neglect.

Key words: Neuromuscular electrical stimulation, Subluxation, Shoulder, Cerebrovascular accident

Introduction

Shoulder pain in hemiplegic patients is a common complication with stroke¹⁾, and it interferes with rehabilitation, produces insomnia, requires added medications, and decreases quality of life (QOL)²⁻⁴⁾. There are many factors contributing to shoulder pain in hemiplegic patients. They include subluxation, reflex sympathetic dystrophy⁵⁾, brachial plexus injury⁶⁾, rotator-cuff tear⁷⁾, and capsulitis⁸⁾. As many as 80% of patients with hemiplegia have been reported to demonstrate a shoulder subluxation⁷⁾. Poulin et al.⁹⁾ reported that the affected upper extremity becomes flaccid in approximately 90 % of the patients immediately after an upper motor lesion, such as a cerebrovascular accident (CVA) . They reported that the incidence of shoulder subluxation varies greatly from 17%¹⁰⁾ to 81%⁷⁾. Basmajian and Bazant¹¹⁾ found in their research using electromyography that the supraspinatus and posterior deltoid muscles played a role in inferior subluxation. We usually detect subluxation starting when the patient begins to sit. The only structures to prevent subluxation are the joint capsule and ligaments during the flaccid phase. Anderson¹²⁾ suggested that stretching of the joint capsule should be avoided during the flaccid phase. We believe that preventing subluxation in the flaccid phase is important, because it potentially reduces pain and/or abnormal sympathetic activity.

The traditional approach to prevent shoulder subluxation is a sling, but the effects are not clear¹³⁾. Faghri and associates¹⁴⁾ suggested that this positioning of the arm interferes with functional activity and may enhance the flexor synergy of the upper extremity.

Some researchers have used Neuro-Muscular Electrical Stimulation (NMES) to prevent shoulder inferior subluxation in stroke patients.

Faghri and associates¹⁴⁾ described the effectiveness of functional electrical stimulation (FES) on arm function, electromyographic activity of the posterior deltoid, range of motion (ROM) , and reduction in subluxation as indicated by roentgenography. They concluded that a FES program was effective in reducing the severity of shoulder subluxation and pain, and in facilitating the recovery of arm function. But their study recruited subjects with preexisting shoulder subluxation, and the time poststroke was 16 to 17 days. Their method did not prevent early shoulder subluxation. Linn and associates¹⁵⁾ reported the effectiveness of electrical stimulation on shoulder subluxation, pain, and motor control. They concluded that electrical stimulation can prevent shoulder subluxation, but the effect was not maintained after the withdrawal of the treatment. They started the electrical stimulation within 48 hours post-onset of the stroke, and patients in the treatment group were immediately put on a regimen of electrical stimulation for 4 weeks. They assessed shoulder subluxation by using a single anterior-posterior radiograph and categorizing subluxation from 1 to 4. They used a line bisecting the glenoid fossa, then measured the distance from the line to the most superior aspect of the head of the humerus. Prevost and associates¹⁶⁾ reported that the measurement was dependent upon the position of the scapula. Chantraine and associates¹⁷⁾ reported on the effectiveness of FES on shoulder subluxation and pain. They concluded that the FES program was significantly effective in reducing the severity of subluxation and pain and may have facilitated the recovery of shoulder function in hemiplegic patients. But the study recruited subjects with a preexisting shoulder subluxation and the time since the stroke onset was from 2 to

4 weeks. They assessed shoulder subluxation only using the de Bats Subluxation Scale (Grade1-3) . They did not describe the level of initial motor function of the affected upper extremity. Wang and associates¹⁸⁾ reported that patients with hemiplegia of a short duration were effectively trained for motor recovery.

The previous studies suggested the effectiveness of NMES for flaccid hemiplegic shoulders, but there were few studies on the prevention of shoulder subluxation in the flaccid phase using a cross-over design.

The purpose of our study was to assess the effectiveness of NMES immediately after stroke to prevent shoulder inferior subluxation, pain, decreased motor function, abnormal muscle tone, ROM limitations, and muscular atrophy in a randomized controlled fashion using a cross-over design.

MATERIALS AND METHODS

Subjects

The selection criteria were as follows: 1. no previous shoulder pathology and no present shoulder subluxation; 2. motor function level at Brunnstrom's recovery stage of < 5; 3. no cardiac pacemaker and/or severe heart disease; 4. no dementia and/or severe aphasia; 5. no pregnancy; and, 6. initial diagnosis and assessments completed within 48 hours after stroke onset. Patients with bilateral hemiplegia, tumor, cerebral metastasis and traumatic brain injuries were excluded. In this study, a total of 44 patients with hemiplegia (19 men, 25 women) were selected. They were all diagnosed as CVA: 26 with CVA due to cerebral infarction, and 18 with CVA due to cerebral hemorrhage. We used the stratified random allocation method to assign the 44 patients to experimental (14 women, 8 men) and control (11 women, 11

men) groups, so each group consisted of 22 patients. All subjects signed a form giving their informed consent before participating in this study. In the experimental group, a patient withdrew from this study due to pneumonia after 2 weeks of intervention. In the control group, a patient withdrew from this study due to a transfer to an other hospital, for personal reasons, after 3 weeks of intervention. Therefore, 21 patients in each group completed this study. The mean age of the experimental group was 70 years and 72 years for the control group.

Study Design

Patients in the experimental group received conventional physical therapy, occupational therapy and NMES treatment immediately after the initial assessments, and then they were treated for 6 - 7 weeks. After finishing, 8 patients were treated for 1 - 2 weeks by conventional physical therapy and occupational therapy, withdrawing the NMES. Patients in the control group received conventional physical therapy and occupational therapy for 6 - 7 weeks. After finishing, 5 patients in the control group were given additional NMES treatments. Both groups received conventional physical therapy and occupational therapy, consisting of ROM exercises, stretching exercises, strengthening exercises and other functional exercises during this study. None of the patients in either group used a sling during this study.

NMES

The NMES unit we employed was the Dynamid DM2500 (MINATO MEDICAL SCIENCE Co.,Ltd. JAPAN) . The parameters of this unit were: carrier frequency 2500Hz, burst frequency 40 to 60 Hz, ramp up time 3 sec, ramp down time 2 sec, and current type burst-

modulated alternating current, on time 10 sec, off time 2 sec. We used adhesive electrodes (5 × 5cm, PALS, Platinum, Axelgaard Manufacturing Co., Ltd. USA) . One electrode was placed over the motor point of the supraspinatus muscle to minimize activation of the upper trapezius muscle, and the other electrode was placed over the insertion of the supraspinatus muscle. Another two electrodes were placed over the origin and insertion of the posterior deltoid muscle. Before we applied the electrodes, we searched for the motor points carefully, so we were able to apply the center of the electrodes to the motor points. The NMES intensity was set to obtain the desired minimum motion of humeral elevation with some abduction and extension to pull the head of the humerus into the glenoid cavity and not to induce fatigue. Stimulation frequency was set between 40 and 60 Hz, according to discomfort. Subjects received the NMES treatments a total of 5 hours per day, 5 days per week. Adhesive electrodes were changed daily in order to ensure low impedance contact. We checked the skin daily after each treatment.

Assessment

Motor function. Motor function was assessed by using the Brunnstrom's recovery stages¹⁹⁾. An ordinal scale was used to express paralysis: 1 for no movement; 2 for associated movement; 3 for synergistic movement; 4 for beginning separated movement; 5 for ability to perform separate movements; and 6 for ability to perform completely. Assessment was always performed by the same physical therapist once a week.

Muscle tone. Arm muscle tone was assessed using a modified Ashworth scale for spasticity²⁰⁾. This scale graded muscle tone from 0 to 4: 0 for

no increase in muscle tone; 1 for slight increase in muscle tone manifested by a catch and release or by minimal resistance at the end of the range of motion when the affected part is moved in flexion or extension; 1+ for slight increase in muscle tone, manifested by a catch, followed by minimal resistance through the remainder (less than half) of the ROM; 2 for a more marked increase in muscle tone through most of the ROM, but the affected part moved easily; 3 for considerable increase in muscle tone, passive movement difficult; and, 4 for affected part being rigid in flexion or extension. For this assessment, the patients were positioned supine on a bed, muscle tone was assessed by stretching the elbow joint from a flexed position to an extended position. Assessment was always performed by the same physical therapist once a week.

ROM. ROM of the shoulder was assessed using a standard goniometer. For this assessment, the patients were positioned supine on a bed; the tester measured passive flexion, abduction and external rotation, moving the part slowly to the threshold of pain. Assessment was always performed by the same physical therapist once a week.

Brachial circumference. Bilateral brachial circumferences were measured using standard tape placed around the upper arm at the axillary fold perpendicular to the long axis of the upper arm. The values obtained from subtracting the circumference of the affected side from the non-affected side were used. Assessment was always performed by the same physical therapist once a week.

Subluxation. All radiological measurements

were obtained with a 45° oblique view, centered at the glenohumeral joint, and taken with the hemiplegic arm unsupported in a sitting position¹⁶⁾. The distance between the source of the x-ray and the patient was kept at one meter.

We measured the vertical distance between the apex of the humeral head and the inferior border of the glenoid fossa using a standard ruler, as described by Prevost and associates (Figure I)¹⁶⁾.

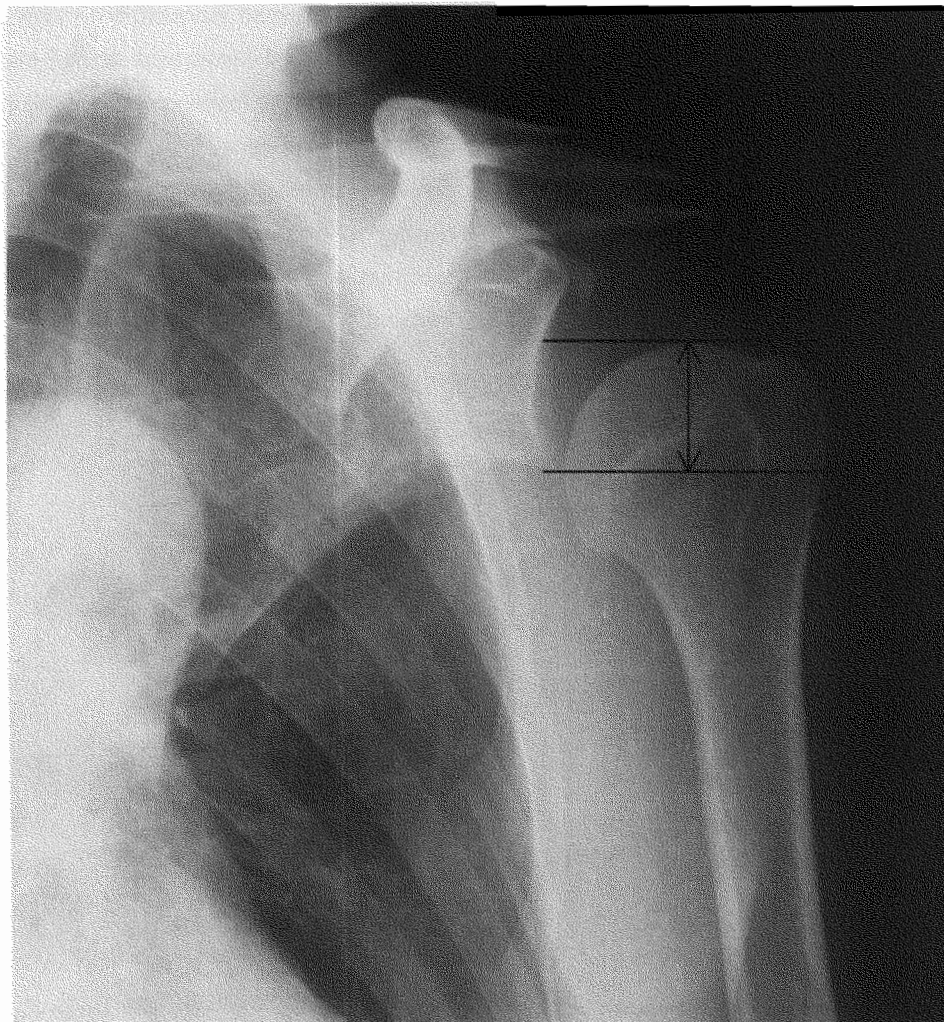


Fig I. Measurement of subluxation of the affected shoulder. We measured the vertical distance between the apex of the humeral head and the inferior border of the glenoid fossa using a standard ruler.

No NMES treatment was performed for 24 hours before the final x-ray was taken to eliminate possible short-term effects of facilitation. All x-rays were evaluated by the same designated investigator using a portable viewing box.

Data analysis.

The Wilcoxon rank sum test and independent t-test were used to compare the differences between the groups at the base-line and before cross-over. Because the variables of arm motor function and muscle tone were measured with an ordinal scale, the Wilcoxon rank sum test for non-parametric statistical analysis was used. The Wilcoxon signed rank test was used to compare

the differences between before and after cross-over for all variables. In all cases the criterion for significance was set at $p < 0.05$.

circumferences ($p < 0.0001$), and subluxations ($p < 0.0001$) (Figure II, III)

RESULTS

There were no differences between the groups at the base-line as determined by the Wilcoxon rank sum test and independent t-test ($p > 0.33$).

After finishing 6 to 7 weeks of treatment, there were no significant differences between the groups in either motor function or muscle tone ($p > 0.74$). But there were significant differences in all ROMs ($p < 0.0001$), brachial

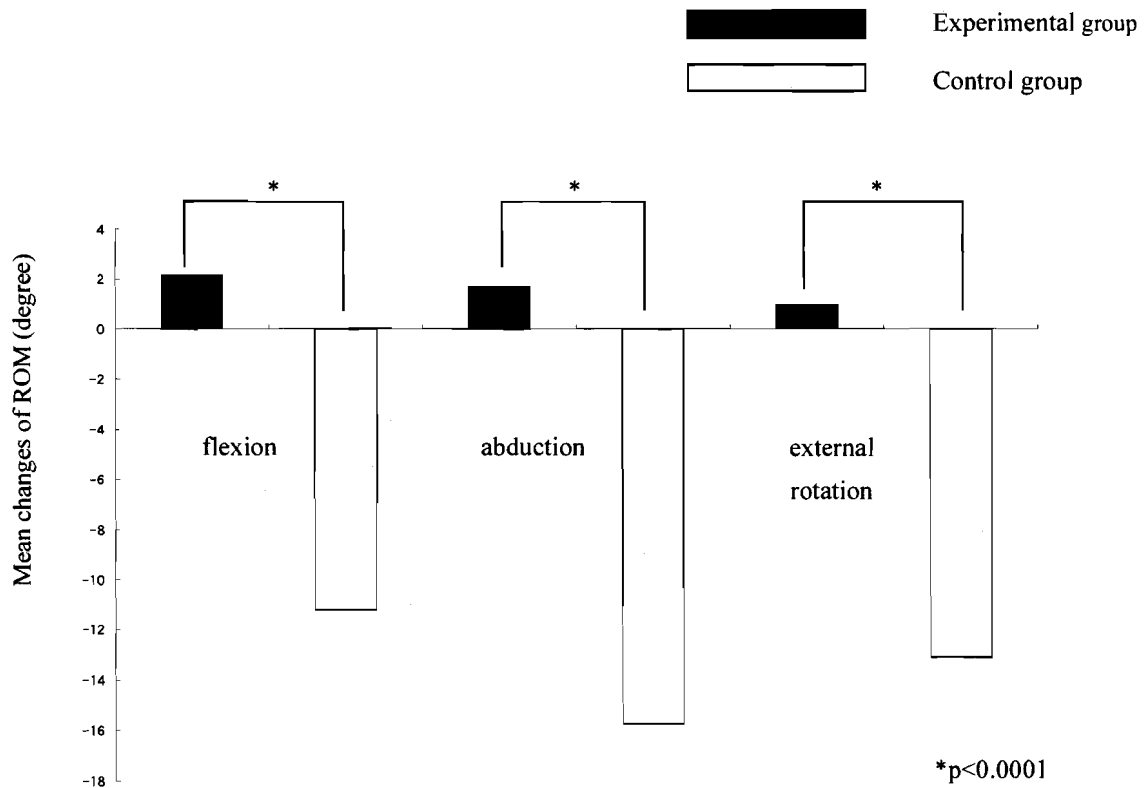


Figure II Mean changes of ROM after 6 to 7 weeks treatment

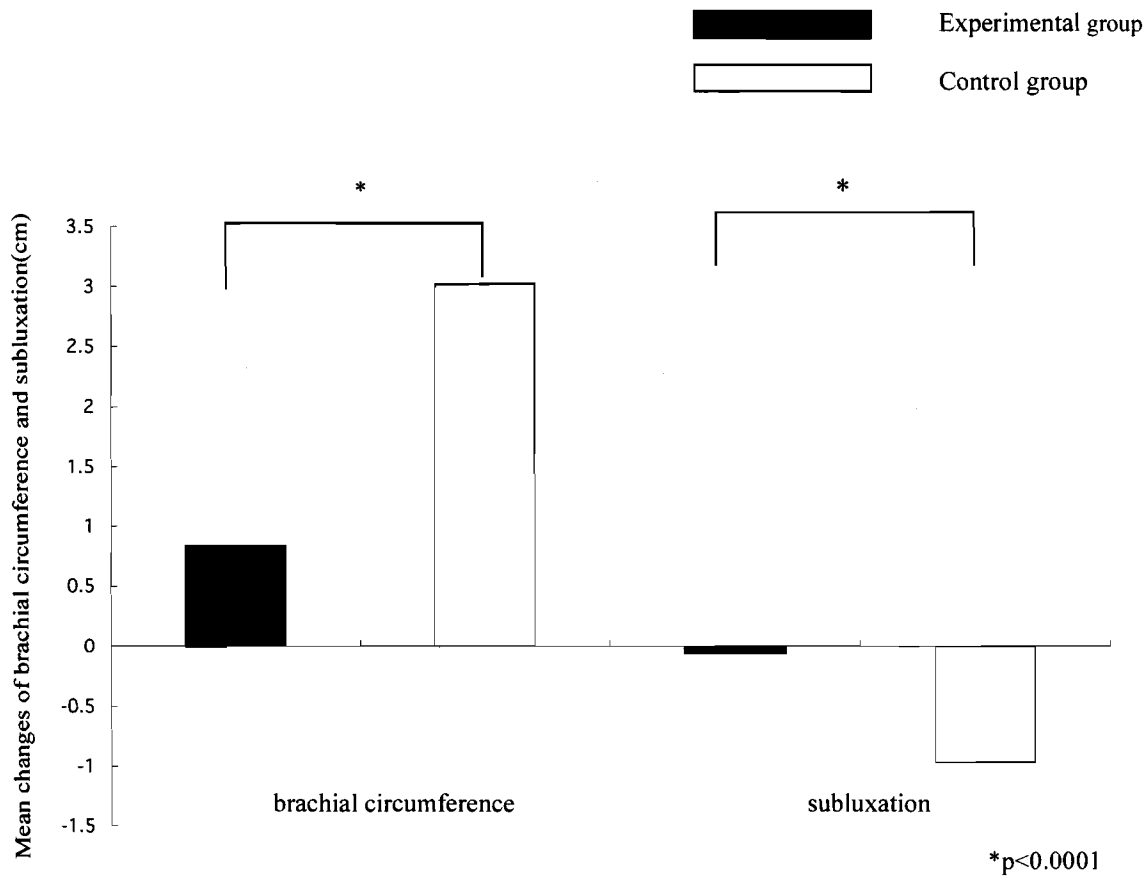


Figure III Mean changes of brachial circumference and subluxation after 6 to 7 weeks treatment

The control group demonstrated a loss of passive ROM progressively over the 6 - 7 weeks, but the experimental group maintained their ROM, except for two patients with severe asomatognosia and unilateral spatial neglect (mean decrease -10 degrees respectively) . The upper extremity muscle atrophy of both groups increased during the research program, but it was significantly mild in the experimental group. Eleven patients did not demonstrate a subluxation of the shoulder, 8 patients in the experimental group developed a subluxation (mean -0.3cm) , and 2 patients with

asomatognosia and unilateral spatial neglect developed a marked subluxation (mean -1.3cm) .

After withdrawal of the NMES treatment in the experimental group, there were no significant differences between before and after withdrawal of the NMES treatment in either motor function, muscle tone, ROM, or brachial circumference ($p>0.11$) . All patients developed a significant subluxation of the shoulder after the withdrawal of NMES for 1 to 2 weeks (mean -1.0cm, $p<0.02$) (Table I) .

Table I . Subluxation of the affected shoulder in the experimental group before and after cross-over

Subjects No.	Before cross-over (cm)	After cross-over (cm)
1	2.5	1.5
2	2.7	2.0
3	3.0	2.3
4	3.6	2.5
5	3.6	2.3
6	3.1	2.2
7	3.8	2.4
8	3.3	2.1

*mean changes -1.0cm, P<0.02

Two patients recovered motor function up to the stage 5 level, but subluxation of the shoulder developed (subject 1; -1.0cm, subject 2; -0.7cm, respectively) .

There were no significant differences between before and after starting the NMES treatment in either motor function, muscle tone, ROM, or brachial circumference in the control group ($p>0.11$) . However, all 5 patients in the control

group, after starting the NMES treatment, revealed a significant improvement in the subluxation of the shoulder after 1 to 2 weeks of additional NMES treatment ($p<0.05$) (Table II) .

Table II . Subluxation of the affected shoulder in the control group before and after cross-over

Subjects No.	Before cross-over (cm)	After cross-over (cm)
1	1.9	3.3
2	1.5	3.0
3	2.0	3.2
4	1.6	3.3
5	2.4	3.8

*mean changes 1.4cm, p<0.05

DISCUSSION

Some researchers reported that NMES facilitates recovery of arm function^{14,17,18)}, but we did not find any beneficial effects on arm function at all. It was expected that the application of NMES would prevent subluxation

and maintain normal shoulder alignment, but we do not believe that it can directly improve motor function.

There were significant differences in ROM, brachial circumference, and subluxation between the groups after 6 - 7 weeks of

treatment. In the experimental group, we found that the NMES treatment could prevent subluxation considerably, and we assume that preventing subluxation is important for maintaining ROM and preventing muscle atrophy. But two patients with severe asomatognosia and unilateral spatial neglect in the experimental group developed subluxation and a decrease in ROM. They tended to ignore their affected arm during ADL, which we believe could have caused the subluxation and decreased ROM. It was suggested that the subluxation of the patients with severe asomatognosia and unilateral spatial neglect should be treated by NMES plus other treatment procedure. Reduction of pain is often considered to be reflected by an increase in passive ROM, especially in external rotation²¹⁾. We believed that the pain in the experimental group was milder than that of the control group. Two patients in the experimental group developed subluxation after the withdrawal of NMES, in spite of achieving a stage 5 motor function level. This may provide useful information on what level of motor function is to be treated by NMES and to consider withdrawal of NMES. We observed that most patients at the stage 5

level do not develop a subluxation in their affected shoulders. But we should continue to pay attention to the affected shoulders of patients of who are at the stage 5 level. Some researchers recently reported the effects of constraint induced movement therapy on chronic CVA patients, and the recovery of motor function seems to continue longer than reported previously^{22,23)}. Therefore, we believe that preventing subluxation immediately after a CVA onset is important for further recovery of motor function. The subluxation in eight patients in the experimental group exacerbated after the withdrawal of 1 - 2 weeks of NMES; we did not find any carry-over effect on the subluxation of the shoulder after only 1 to 2 weeks. We need to develop a more compact instrument for home use for the patients with a prolonged flaccid phase, because there is no carry-over effect. In addition, we should do further research on the use of NMES over a longer period of times.

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REFERENCES

1. Joynt RL. The source of shoulder pain in hemiplegia. *Arch Phys Med Rehabil* 73: 409-413, 1992
2. Calliet R. *The shoulder in hemiplegia*. Philadelphia, Davis, 1980.
3. Wade DT. Stroke: rehabilitation and long-term care. *Lancet* 339: 791-793, 1992
4. Griffin JW. Hemiplegic shoulder pain. *Phys Ther* 66: 1884-1893, 1986
5. Tepperman PS, Greyson ND, Hilbert Let al. Reflex sympathetic dystrophy in hemiplegia. *Arch Phys Med Rehabil* 65: 442-447, 1984
6. Chino N. Electrophysiological investigation on shoulder subluxation in hemiplegics. *Scand J Rehabil Med* 13: 17-21, 1981
7. Najenson T, Yacubovich E, Pikielni SS. Rotator cuff injury in shoulder joints of hemiplegic patients. *Scand J Rehabil Med* 3: 131-137, 1971
8. Hakuno A, Sashika H, Ohkawa T. Arthrographic findings in hemiplegic shoulders. *Arch Phys Med*

- Rehabil 65: 706-711, 1984
9. Poulin de Courval L, Barsauskas A, Berenbaum B et al. Painful shoulder in the hemiplegic and unilateral neglect. *Arch Phys Med Rehabil* 71: 673-676, 1990
 10. Fitzgerald-Finch OP, Gibson II. Subluxation of the shoulder in hemiplegia. *Age Ageing* 4: 16-18, 1975
 11. Basmajian JV, Bazant FJ. Factors preventing downward dislocation of the adducted shoulder joint. *J Bone Joint Surg* 41A: 111-117, 1959
 12. Anderson LT. Shoulder pain in hemiplegia. *Am J Occup Ther* 39: 11-19, 1985
 13. Griffin J, Reddin G. Shoulder pain in patients with hemiplegia. A literature review. *Phys Ther* 61: 1041-1045, 1981
 14. Faghri PD, Rodgers MM, Glaser RM et al. The effects of functional electrical stimulation on shoulder subluxation, arm function recovery, and shoulder pain in hemiplegic stroke patients. *Arch Phys Med Rehabil* 75: 73-79, 1994
 15. Linn SL, Granat MH, Lees KR. Prevention of shoulder subluxation after stroke with electrical stimulation. *Stroke* 30: 963-968, 1999
 16. Prevost R, Arsenault AB, Dutil E, Drouin G. Shoulder subluxation in hemiplegia: a radiologic correlational study. *Arch Phys Med Rehabil* 68: 782-785, 1987
 17. Chantraine A, Baribeault A, Uebelhart D et al. Shoulder pain and dysfunction in hemiplegia: effects of functional electrical stimulation. *Arch Phys Med Rehabil* 80: 328-331, 1999
 18. Wang RY, Yang YR, Tsai MW et al. Effects of functional electric stimulation on upper limb motor function and shoulder range of motion in hemiplegic patients. *Am J Phys Med Rehabil* 81: 283-290, 2002
 19. Kathryn AS. *Brunnstrom's Movement Therapy in Hemiplegia: A Neurophysiological Approach*. Philadelphia, Lippincott, 1992
 20. Bohannon RW, Smith MB. Interrater reliability of a modified Ashworth scale of muscle spasticity. *Phys Ther* 67: 206-207, 1987
 21. Andrews AW, Bohannon RW. Decreased shoulder range of motion on paretic side after stroke. *Phys Ther* 69: 768-772, 1989
 22. Bonifer N, Anderson KM. Application of constraint-induced movement therapy for an individual with severe chronic upper-extremity hemiplegia. *Phys Ther* 83: 384-398, 2003
 23. Kunkel A, Kopp B, Muller G et al. Constraint-induced movement therapy for motor recovery in chronic stroke patients. *Arch Phys Med Rehabil* 80: 624-628, 1999