Effects of Bilateral Passive Range of Motion Exercise on the Function of Upper Extremities and Activities of Daily Living in Patients with Acute Stroke

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Abstract. [Purpose] To evaluate the effects of early passive range of motion exercise on the function of upper extremities and activities of daily living in patients with acute stroke. [Methods] A total of 37 patients with acute stroke in intensive care units, were assigned to the experimental group (n=19) and control group (n=18). The experimental group performed passive range of motion exercise twice a day, for 4 weeks, immediately after a pretest; the patients in the control group performed the range of motion exercise in the same manner for 2 weeks beginning 2 weeks after the pretest. The functions of upper extremities (edema, range of motion), manual function, and activities of daily living of both groups were measured before and at four weeks after the intervention. [Results] The experimental group showed a significant decrease in the edema of upper extremities compared with the control group. It also showed a significant increase in the range of motion, function of upper extremities, and the activities of daily living compared to the control group. [Conclusion] Passive range of motion exercise in the early stage can improve the function of upper extremities and activities of daily living in patients with acute stroke.

Key words: Stroke, Range of motion, Upper extremity

INTRODUCTION

Stroke is the third leading cause of death and a major cause of disability among persons age over 70 in North America3. Despite the advancement in medical technology and improved awareness of the general public of health issues in South Korea, acute stroke reigned as the number two cause of death in 20112. Over 90% of stroke survivors suffer various impairments, such as clouded consciousness, hemiplegia, and declined sensation, depending on the extent of damage in the brain and the cause3; 10% of stroke patients fully recover after the acute phase treatment, 15–20% die, and the remaining 70–75% do not recover completely and live with permanent hemiplegia9. Hemiplegia caused by acute stroke leads to stiffness, paralysis, weakened muscular strength, and consequently reduced range of motion (ROM) and function of the upper extremities, negatively affecting activities of daily living (ADL), such as eating, dressing, washing, and balancing5. Improving the functions of the upper extremities requires rehabilitation of not only proximal functions but also minute functions, and in the case of hemiplegia, rehabilitation of the affected side becomes even trickier due to over-reliance on the unaffected side and complete neglect of the affected part7. Weakening of one of the upper extremities induces physical pain, edema of upper extremities, and joint contracture that may limit ADL. Therefore, an appropriate amount of therapeutic exercise and maintaining the correct positioning are essential in improving ADL and functions of the upper extremities.

The most important factor in predicting recovery through remedial exercise is the initial degree of paralysis. Relatively speaking, the recovery is easier in the initial stages of the paralysis before the limiting paralysis symptoms occur, so partaking in remedial exercise in the first 3–4 days or at least within the first 7 days increases muscular flexibility and lymph circulation and reduces edema9, 10. While the benefits of early remedial exercise are clear, they are not widely applied because most patients hospitalized in neurosciences intensive care units (NSICUs) are in critical conditions in which their lives are threatened and are unable to express their symptoms with clarity themselves, making it difficult for the medical professional to consider remedial options11. Generally, acute stroke patients do not start their remedial efforts until 10–14 days after the stroke; however, earlier therapeutic measures can minimize the amount of permanent impairments due to the stroke and the time required for recovery and ultimately help more patients return to a normal life9–11.

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Several therapeutic measures can be administered to improve the upper extremity functions of stroke patients. Functional electrical stimulation requires specialized facilities furnished with appropriate equipment and is difficult to perform on acute stroke patients who tend to be confined to their beds in unstable conditions. Constraint-induced therapy can be applied to patients who are conscious with some ability to move for 6 hours a day for 2 weeks and is focused on improving the nerve functions around the affected area. It is problematic to administer in the NSICU, and forced movement of the affected areas can cause the patients emotional discomfort. Compared with the previous options, ROM exercise does not require specialized equipment or the patient to be conscious in order to participate, making them an appropriate remedial method for nurses to apply in the NSICU even in the case of patients who have recently suffered a stroke. Yang et al. (2006) reported about the effects of manual joint ROM exercise targeting affected areas on alleviation of edema in the hands and stiffness of the upper extremities in acute stroke patients. However, recent studies found that hemiplegic patients have impairments of sensation and mobility even on their unaffected sides and that the activities of the unaffected sides have an impact on the shrinkage of the affected area. Therefore, application of therapeutic exercise to both sides of the upper extremities is important.

This study aims to evaluate the effects of earlier passive ROM exercise administered in the NSICU on the function of upper extremities and ADL in patients with acute stroke and the validity of such exercise as an appropriate nursing intervention.

**SUBJECTS AND METHODS**

**Subjects**

The following criteria were used to recruit participants diagnosed with acute stroke within the previous 72 hours from among patients who were hospitalized in the NSICUs of three university hospitals located in Seoul and Gyeong-gi Province, South Korea: below G3 in a muscle strength test; no existing conditions that would disrupt medical treatment; no amputations, disfigurements, external wounds, or other deformations with regard to either upper extremity; and patient or guardian consented to the patient’s participation in the study. Subjects chosen based on the criteria above were assigned to either the control or experimental group through a random coin toss. Power analysis was performed to detect the likelihood that the study would yield a significant effect. In total, 18 participants for each group were needed to detect the average difference between the two groups with an effect size of 0.50, alpha set at 0.05, and power of the test at 0.80. The projected dropout rate was set at 30%, considering factors such as average length of stay in the neurological intensive care unit and transfers to other hospitals, and for the initial stage of the study, 25 participants for the experimental group and 26 for the control group were recruited. At the end, the study group consisted of 37 participants in total, with 19 in the experimental group and 18 in the control group. There was no significant difference in general characteristics or symptoms relating to the disease between the groups (Table 1).

**Methods**

The bilateral passive ROM exercise administered in this study were developed by a researcher with 12 years of experience in an NSICU based on a related study and expert advice and were then reviewed and validated by a professor of rehabilitative medicine, a professor of nursing, and a physical therapist. In order to minimize the study’s margin of error, the researcher and one assistant learned the ROM exercise routines and adjusted each move to a level comfortable for patients through clinical trials before beginning the study. The patients in the experimental group performed the passive ROM exercise twice a day – once in the morning and once at evening – 5 days per week for 4 weeks; for each of these 15-minute-long sessions, each move of the exercise routine was repeated 10 times. The duration of each session was determined based on Suh's (1999) 4-week study on exercise that improved flexibility and stability of body posture. The exercise routine was sequenced in a way that the active upper extremities were worked out before the paralyzed side, and consisted of: shoulder joint exercise (forward and side elevation of the upper extremities, internal and external rotation of the shoulder) elbow exercise (bending and extending), wrist exercise (flexion, extension, radial deviation, and ulnar deviation), and finger exercise (flexion and extension). The control group followed the existing remedial guidelines and partook in the ROM exercise following the same procedure as the experimental group 2 weeks after their diagnosis. The range of movement for the exercise was limited to the point of joint resistance.

**Table 1. General characteristics of the subjects**

| Characteristics | Exp (n=19) | Cont (n=18) |
|-----------------|-----------|------------|
| Age (year)‡     | 59.2±14.1 | 63.0±16.2  |
| Gender (Male/ Female) | 14/5 | 8/10  |
| Glasgow Coma Scale score | 10.3±3.0 | 9.3±3.0 |
| Diagnosis (Hemorrhage/ infarction) | 13/6 | 8/8  |
| Affected extremities (Right/ Left) | 9/10 | 9/9  |
| Affected lesion* (RtCb/Lt Cb/Cbl) | 7/11/1 | 9/8/1  |
| MMT (affected)* | 1.8±3.9 | 2.0±6.4  |

Grade 0 1 0  
Grade 1 5 2  
Grade 2 10 14
Grade 3 3 2  

MMT (unaffected) 4.7±4.9 4.4±1.4  
Grade 4 6 10  
Grade 5 13 8  

Brunnstrom recovery stage 1.1±10.6 1.3±5.7  
1 17 13  
2 2 5  

Exp=Experimental group, Cont=Control group, MMT=Manual Muscle Test, Cb=Cerebral, Cbl=Cerebellar  
* Fisher’s exact test, † Wilcoxon signed-rank test
for patients who were unconscious, and within the range of comfort for patients who were conscious.

A tape measure was used to measure upper extremity edema; the circumference of the index finger, wrist, and elbow on both sides was measured twice (in mm) and then averaged. Only the ROM of the paralyzed upper extremities was measured, as the unaffected side demonstrated a normal ROM. The angle of flexion, extension abduction, pronation, and supination of the shoulder; the flexion, pronation, and supination of the elbow; and the flexion, extension, radial deviation, and ulnar deviation of the wrist were measured. For measuring the ROM, a plastic goniometer (KoreaMetrics, 2007) was used. In an anatomically neutral position, the angle of each joint was measured twice, and the values were then averaged. The manual function test (MFT) was performed using a measuring procedure especially designed for evaluating MFT. The procedure consisted of 4 moves from the exercise routine mentioned above (front and side elevation of the upper extremities, touching of the occiput with the palm, and touching of the dorsum with the palm), 2 verification categories (holding and grasping), and 2 categories testing for the level of control over the fingers (moving a cube and the pegboard test). Under these categories were 32 subtests, and one point was given for each subtest performed by the patient for a total of 32 points. The final score was multiplied by 3.125 to convert it to a score out of 100 points and designated the MFT score. The reliability was expressed by Cronbach’s α of 0.94.

From the procedure for evaluating the functional capacity of a patient in rehabilitation, developed by Granger, Cotter, Hamilton, Fielder, and Hans (1990) and adapted by Park and Sohng (2005), 6 categories for self-care for an acute stroke patient were used to measure the ADL. Included in the self-care categories were eating, personal hygiene, bathing, dressing oneself (top and bottom), and using the toilet, with scores ranging from 7 to 42. Higher score indicated higher level of independence, and the reliability of the measure was good, with a Cronbach’s α of 0.95.

The present study meets the ethical standards of the Declaration of Helsinki (1975, revised 1983) and received Institutional Review Board approval from C University hospitals, located in three different locations in Seoul and Gyoeng-gi Province, South Korea. The study took place between 4 November 2007 and 31 August 2008. Pretest measurements of general characteristics, remedial stage, and the level of upper extremity functions for both groups of participants were performed by Research Assistant A, who was not aware of which group the participants belonged to. Research Assistant B, who did not have any knowledge of the pretest measurements, administered the ROM exercise to the experimental group, which included patients with mobile upper extremities to those that were paralyzed, in the order of the shoulders, elbows, wrists, and fingers. Without giving any information about the rest of the study, the same treatment was given to the control group 2 weeks later. Research Assistant A measured the level of upper extremity function (upper extremity edema, ROM, acute stroke upper extremity function) and ADL of both groups 2 and 4 weeks after the initial test. To be able to continue with the exercise after the study without the researcher’s supervision, patients and their guardians were provided with training on how to conduct the ROM exercise, and were given brochures and video clips for reference.

The collected data were analyzed using the SAS V 8.2 software. Pretest general characteristics, disease-related attributes, level of upper extremity functions (upper extremity edema, articular ROM), acute stroke upper extremity functions, and ADL were tabulated into frequencies, percentages, averages, and standard deviation. In order to ensure homogeneity, consecutive data were tested for normality using the t-test or Wilcoxon signed-rank test; the x²-test and Fisher’s exact test were used for used for discrete data. Repeated measures ANOVA was used to evaluate the pre- and posttest differences of the two groups, and posttest validation was done by Bonferroni test. ANCOVA was used for shoulder flexion, extension, and ulnar deviation when there were pretest differences between the two groups.

RESULTS

For the experimental group, the circumference of the finger on the affected side decreased, from 73.3 mm at the pretest to 69.2 mm at 2 weeks and 65.9 mm at 4 weeks, whereas the control group showed an increase from 73.7 mm at the pretest, to 77.6 mm at 2 weeks and 77.9 mm at 4 weeks (p=0.001). The change after 4 weeks, a 7.4 mm decrease in the experimental group and a 4.2 mm increase in the control group, differed between the two groups (p=0.002), and the changeable aspects between the two groups in terms of time showed reciprocal action (p=0.001). The circumference of the wrist decreased over time in the experimental group, from 171.6 mm at the pretest to 17.4 mm at 2 weeks and 163.7 mm at 4 weeks, while it increased over time in the control group, from 173.8 mm to 180.5 mm at 2 weeks and 180.5 mm at 4 weeks after the test (p=0.022). The 4-week posttest figures show a 7.9 mm decrease in the experimental group and a 6.7 mm increase in the control group (p=0.016). The changeable aspects between the two groups in terms of time demonstrated reciprocal action (p=0.001). The circumference of the elbow in the experimental group decreased from 250.7 mm at the pretest to 242.5 mm at 2 weeks and 235.7 mm at 4 weeks (p=0.001), while the control group showed an increase from 251.6 mm to 262.2 mm at 2 weeks and 263.1 mm at 4 weeks. The change at 4 weeks, a 150 mm decrease in the experimental group and a 7.06 mm increase in the control group, showed a 7.4 mm decrease in the experimental group and a 4.2 mm increase in the control group (p=0.001), but there was no difference or reciprocal action between the two groups. The circumference of the elbow in both groups decreased over time (p=0.001) but with no difference or reciprocal action (Table 2).
Flexion of the shoulder in the experimental group increased from 114.1° at the pretest to 116.7° at 2 weeks and 119.0° at 4 weeks, and in the control group, it went from 109.1° at the pretest to 109.8° at 2 weeks and 111.1° at 4 weeks, both with no changeable aspects in relation to time. At 4 weeks, the experimental group showed a 4.9° increase, whereas the control group showed a 2.0° increase, demonstrating that there was some difference (p=0.001); the changeable aspects between the two groups indicated reciprocal action (p=0.001). Regarding shoulder extension, the experimental group demonstrated an increase over time from 25.2° at the pretest to 27.1° at 2 weeks and 29.5° at 4 weeks after the test, and the control group also showed an increase over time, from an initial value of 31.2° to 31.3° at 2 weeks and 31.9° at 4 weeks (p=0.007). The amount of change over 4 weeks differed between the two groups, with the experimental group showing a 4.3° increase and the control group showing a 0.7° increase (p=0.001); there was time-based reciprocal action between the two groups (p=0.001). Shoulder abduction in the experimental group improved from the pretest level of 94.2° to 96.3° at 2 weeks and 98.4° at 4 weeks, whereas in the control group, it increased from the initial 92.7° to 93.0° at 2 weeks and 94.2° at 4 weeks, showing no difference in the amount of change between the two time intervals. There was a difference in the amount of change between the two groups; however, the experimental group displayed a 4.2° increase, while the control group displayed an increase of 1.5° (p=0.001). Reciprocal action over time was witnessed between the two groups (p=0.001). Shoulder pronation in the experimental group increased over time from the initial 51.3° to 53.8° at 2 weeks and 55.6° at 4 weeks. In the control group, it increased over time from 57.7° at the pretest to 58.3° at 2 weeks and 58.8° at 4 weeks, with no difference in value between the two time intervals. The degree of change at 4 weeks between the experimental and control group differed, with the increase in the experimental group measuring at 4.3° and that in the control group measuring 1.1° (p=0.001); there was reciprocal action between the two groups (p=0.001) for shoulder supination, the experimental group demonstrated an increase over time from 44.8° at the pretest to 46.7° at 2 weeks and 48.6° at 4 weeks after the test, while the control group also showed an increase from an initial value of 35.0° to 35.4° at 2 weeks and 36.0° at 4 weeks, with no difference based on time intervals. The amount of change over 4 weeks differed between the experimental group and the control group, as the experimental group showed a 3.8° increase while the control group showed a 1.0° increase (p=0.001); there was reciprocal action between the two groups (p=0.001).

The flexion of the elbow increased in the experimental group over time, from 95.2° to 95.7° at 2 weeks and 99.3° at 4 weeks. The values for the control group also showed an increase from an initial value of 35.6° to 35.4° at 2 weeks and 36.0° at 4 weeks, with no difference based on time intervals. The amount of change over 4 weeks differed between the experimental group and the control group, as the experimental group showed a 3.8° increase while the control group showed a 1.0° increase (p=0.001); there was reciprocal action between the two groups (p=0.001) (Table 3).

### Table 2. Comparison of upper extremities edema between experimental and control groups

| Variables   | Baseline | After 2 wks | After 4 wks |
|-------------|----------|-------------|-------------|
| **Affected (mm)** |          |             |             |
| Finger      | Exp      | 73.3±6.9a,b | 69.2±6.8a   | 65.9±6.7b   |
|             | Cont     | 73.7±6.3a,b | 77.6±6.6a   | 77.9±7.0b   |
| Wrist       | Exp      | 171.6±12.6a,b | 167.4±12.4a | 163.7±11.6b |
|             | Cont     | 173.8±15.2a,b | 180.5±13.4a | 180.5±12.7a |
| Elbow       | Exp      | 250.7±23.2a,b | 242.5±22.0a | 235.7±19.8b |
|             | Cont     | 256.1±29.4a,b | 262.2±26.5a | 263.1±28.0b |
| **Unaffected (mm)** |          |             |             |
| Finger      | Exp      | 69.8±7.7a,b  | 66.5±7.0a   | 64.0±7.0b   |
|             | Cont     | 71.7±5.8a    | 70.3±4.9a   | 67.8±5.1a   |
| Wrist       | Exp      | 167.2±12.9a,b | 164.2±12.7b | 161.2±12.4b |
|             | Cont     | 169.8±12.1a  | 169.0±10.2  | 165.6±9.4b  |
| Elbow       | Exp      | 245.3±21.0a,b | 239.1±21.3a | 233.8±19.5b |
|             | Cont     | 253.3±27.4a,b | 249.5±25.6a | 244.9±24.8b |

Exp=Experimental group, Cont=Control group, a,b =Bonferroni test

### Table 3. Comparison of range of motion of affected shoulder between experimental and control groups

| Variables       | Baseline | After 2 wks | After 4 wks |
|-----------------|----------|-------------|-------------|
| Flexion (°)     | Exp (n=19) | 114.1±13.0a | 116.7±12.8a | 119.0±12.6a |
|                 | Cont (n=18) | 109.1±20.2a | 109.8±20.7 | 111.1±21.1b |
| Extension (°)   | Exp (n=19) | 25.2±5.2a   | 27.1±4.9b   | 29.5±5.3c   |
|                 | Cont (n=18) | 31.2±4.9    | 31.3±4.7    | 31.9±4.8    |
| Abduction (°)   | Exp (n=19) | 94.2±12.0a  | 96.3±12.1b  | 98.4±12.5c  |
|                 | Cont (n=18) | 92.7±13.0a  | 93.0±13.1   | 94.2±13.4b  |
| Internal rotation (°) | Exp (n=19) | 51.3±19.8a  | 53.8±19.5b  | 55.6±19.6c  |
|                 | Cont (n=18) | 57.7±14.8a  | 58.3±14.8b  | 58.8±15.2b  |
| External rotation (°) | Exp (n=19) | 44.8±24.9a  | 46.7±25.3b  | 48.6±25.5b  |
|                 | Cont (n=18) | 35.0±18.2a  | 35.4±18.3   | 36.0±18.3b  |

Exp=Experimental group, Cont=Control group, a,b,c =Bonferroni test
For pronation of the elbow, the experimental group demonstrated an increase over time from 95.2° at the pretest to 95.7° at 2 weeks and 99.3° at 4 weeks after the test, while the control group also showed an increase, from an initial value of 103.6° to 104.5° at 2 weeks and 105.4° at 4 weeks, with no difference in the amount between the time intervals. The amount of change over 4 weeks differed between the two groups, with the experimental group showing a 3.8° increase and the control group showing a 0.8° increase (p= 0.001). Time-based reciprocal action was observed between the two groups (p= 0.001). Elbow supination in the experimental group improved from the pretest level of 53.7° to 56.0° at 2 weeks and 57.3° at 4 weeks, while in the control group, it increased and initial value of 54.6° to 56.1° at 2 weeks and 56.7° at 4 weeks, showing some difference in the amount of change between the two time intervals (p= 0.001). There was a significant difference between the amount of change in the two groups; the experimental group displayed a 3.6° increase, while the control group showed an increase of 1.1° (p= 0.001). Reciprocal action over time was witnessed between the two groups (p= 0.001).

Flexion of the wrist joints for the experimental group increased from the pretest value of 40.3° to 42.0 at 2 weeks and 42.9° at 4 weeks, with no difference based on the time interval. After 4 weeks, the experimental group showed an increase of 2.6°, and the control group an increase of 1.1°, there was a difference between the two groups (p = 0.016), and there was time-based reciprocal action between the two groups (p= 0.033). Wrist extension in the experimental group increased from the pretest level of 36.7° to 42.0° at 2 weeks and 42.9° at 4 weeks, while that in the control group increased from an initial value of 46.0° to 46.6° at 2 weeks and 47.1° at 4 weeks, demonstrating a difference (p= 0.007); there was no different based on varying time intervals. The increase at 4 weeks in the experimental group was 3.4°, and that in the control group was 1.0°; time-based reciprocal action between the two groups was observed (p= 0.001). The ulnar deviation in the experimental group showed an increase from a pretest value of 20.7° to 22.8° at 2 weeks and 24.1° at 4 weeks, while that in the control group increased from 23.1° to 23.5° at 2 weeks and 24.0° at 4 weeks, displaying no change based on time intervals. The results of the two groups at 4 weeks differed (p= 0.001); there was a 3.4° increase in the experimental group versus a 0.9° increase in the control group. The time-based changeable aspects displayed reciprocal action (p= 0.001). The measurements for radial deviation in the experimental group increased from 15.4° at the pretest to 17.0° at 2 weeks and 17.7° at 4 weeks, and in the control group, they increased from 15.5° at the pretest to 15.8° at 2 weeks and 16.1 at 4 weeks; no difference based on varying time intervals was demonstrated. There was a difference between the level of increase between the two groups at 4 weeks (p= 0.001), with the experimental group measurements increasing by 2.3° and the control group measurements increasing by 0.6° (p= 0.001). The time-based changeable aspects between the two groups showed reciprocal action (p= 0.001) (Table 4).

The level of acute stroke upper extremity function in the experimental group increased by 1.58 points between weeks 2 and 4, from 4.75 points to 6.33 points, while that in the control group increased by 0.36 points between 2 and 4 weeks, from 4.93 to 5.29 points; the levels were different between the two groups (p= 0.015). Regarding the front elevation of the upper extremities, the two groups displayed a difference as well (p= 0.017), with the experimental group improving by 0.58 points from 1.00 at week 2 to 1.58 points at week 4, whereas the control group showed a 0.14 point increase.

### Table 4. Comparison of range of motion of affected elbow and wrist between experimental and control groups

| Variables           | Baseline       | After 2 wks    | After 4 wks    |
|---------------------|----------------|----------------|----------------|
|                     | Mean±SD        | Mean±SD        | Mean±SD        |
| **Affected elbow**  |                |                |                |
| Flexion (°)         | Exp (n=19)     | 95.2±35.3a     | 97.7±35.3b     | 99.3±35.1c     |
|                     | Cont (n=18)    | 103.6±16.7a    | 104.0±16.9     | 105.4±16.8b    |
| Supination (°)      | Exp (n=19)     | 46.4±28.2a     | 48.5±28.7b     | 50.2±28.5c     |
|                     | Cont (n=18)    | 49.0±18.9a     | 49.5±19.1      | 49.8±19.0b     |
| Pronation (°)       | Exp (n=19)     | 53.7±16.1a     | 56.0±16.0b     | 57.3±15.7c     |
|                     | Cont (n=18)    | 64.6±11.7a     | 65.1±11.7      | 65.7±11.7b     |
| **Affected wrist**  |                |                |                |
| Flexion (°)         | Exp (n=19)     | 40.3±7.4a      | 42.0±7.3b      | 42.9±7.0c      |
|                     | Cont (n=18)    | 46.0±3.6a      | 46.6±3.6       | 47.1±3.7b      |
| Extension (°)       | Exp (n=19)     | 36.7±7.3a      | 38.6±6.6b      | 40.1±6.6c      |
|                     | Cont (n=18)    | 37.0±7.2a      | 37.5±7.1       | 38.0±7.3b      |
| Ulnar deviation (°) | Exp (n=19)     | 20.7±5.0a      | 22.3±4.5b      | 24.1±4.2c      |
|                     | Cont (n=18)    | 23.1±2.3a      | 23.5±2.1       | 24.0±2.5b      |
| Radial deviation (°)| Exp (n=19)     | 15.4±5.8a      | 17.0±5.3b      | 17.7±5.2c      |
|                     | Cont (n=18)    | 15.5±3.8a      | 15.8±3.7       | 16.1±3.8b      |

Exp=Experimental group, Cont=Control group, wks=weeks, a,b,c =Bonferroni test
increase from 1.12 points at week 2 to 1.36 points at week 4. Points in the experimental and control groups for side elevation of the upper extremities, touching of the occiput with the palm, touching of the dorsum with the palm, and grasping did not display much difference, and obtaining measurements for picking up objects, moving a cube, and the pegboard test proved to be difficult (Table 5).

The self-care points based on the 6 ADL criteria showed a difference between the two groups (p = 0.001), with the experimental group showing an increase of 1.37 points, from 16.84 points at week 2 to 18.21 at week 4, and the control group showing a 0.17 point increase, from 12.50 at week 2 to 12.67 points at week 4. Points earned for eating also differed (p = 0.001), as the experimental group showed a 0.58-point improvement between week 2 and week 4, from 3.79 points to 4.37 points, while no change was observed in the control group. Points for putting on one’s own top differed between the two groups (p = 0.043); an increase of 0.32 points was observed in the experimental group between week 2 and week 4, from 3.2 points to 3.53 points, while an increase of 0.06 points was observed in the control group, from 2.44 points at week 2 to 2.50 points at week 4 (Table 5).

**DISCUSSION**

Bilateral passive ROM exercise prolong muscular expansibility while preventing shrinkage and improve the patient’s ROM and flexibility; they can be conducted through the efforts of a third person in the case of unconscious patients. This study investigated the effects of bilateral passive ROM exercise on the level of upper extremity function and ADL based on exercise routines that could be administered by a nurse to an acute stroke patient in the NSICU independent from the constraints of time, place, available equipment, or the consciousness of the patient; 15-minute exercise routines were performed twice a day, 5 times a week, for 4 weeks.

Stroke is a general term that refers to cerebrovascular diseases caused by irregular supply of blood to the brain, and most stroke patients experience paralysis, especially in the upper extremities. Poststroke neurological recovery

**Table 5. Comparison of manual function test and activity of daily living between experimental and control groups**

| Variables                  | After 2 wks Mean±SD | After 4 wks Mean±SD | Difference (Post-Pre) Mean±SD |
|----------------------------|---------------------|---------------------|------------------------------|
| MFT (Total score)          |                     |                     |
| Exp (n=12)                 | 4.75±0.45           | 6.33±1.67           | 1.58±1.44                    |
| Cont (n=14)                | 4.93±0.73           | 5.29±0.99           | 0.36±0.63                    |
| Task FE                    |                     |                     |
| Exp (n=12)                 | 1.00±0.00           | 1.58±0.51           | 0.58±0.51                    |
| Cont (n=14)                | 1.21±0.43           | 1.36±0.50           | 0.15±0.36                    |
| Task LE                    |                     |                     |
| Exp (n=12)                 | 1.00±0.00           | 1.42±1.51           | 0.42±0.51                    |
| Cont (n=14)                | 1.00±0.00           | 1.14±0.36           | 0.14±0.36                    |
| Task PO                    |                     |                     |
| Exp (n=12)                 | 1.00±0.00           | 1.25±0.45           | 0.25±0.45                    |
| Cont (n=14)                | 1.00±0.00           | 1.00±0.00           | 0.00±0.00                    |
| Task PD                    |                     |                     |
| Exp (n=12)                 | 1.00±0.00           | 1.00±0.00           | 0.00±0.00                    |
| Cont (n=14)                | 1.00±0.00           | 1.00±0.00           | 0.00±0.00                    |
| Task GR                    |                     |                     |
| Exp (n=9)                  | 1.00±0.00           | 1.30±0.48           | 0.30±0.48                    |
| Cont (n=10)                | 1.00±0.00           | 1.10±0.32           | 0.10±0.32                    |
| Self care (Total score)    |                     |                     |
| Exp                        | 16.84±9.62          | 18.21±10.10         | 1.37±1.26                    |
| Cont                       | 12.50±5.49          | 12.67±5.75          | 0.17±0.51                    |
| Feeding                    |                     |                     |
| Exp                        | 3.79±1.99           | 4.37±2.34           | 0.58±0.51                    |
| Cont                       | 3.28±1.67           | 3.28±1.67           | 0.00±0.00                    |
| Personal hygiene           |                     |                     |
| Exp                        | 2.74±1.76           | 2.89±1.85           | 0.15±0.37                    |
| Cont                       | 1.89±1.28           | 1.94±1.26           | 0.05±0.24                    |
| Bathing                    |                     |                     |
| Exp                        | 1.74±1.28           | 1.79±1.36           | 0.05±0.23                    |
| Cont                       | 1.11±0.32           | 1.11±0.32           | 0.00±0.00                    |
| Upper dressing             |                     |                     |
| Exp                        | 3.21±1.78           | 3.53±1.84           | 0.32±0.48                    |
| Cont                       | 2.44±1.29           | 2.50±1.42           | 0.06±0.24                    |
| Lower dressing             |                     |                     |
| Exp                        | 3.21±1.78           | 3.47±1.81           | 0.26±0.45                    |
| Cont                       | 2.44±1.29           | 2.50±1.42           | 0.06±0.24                    |
| Toilet                     |                     |                     |
| Exp                        | 2.16±1.74           | 2.16±1.74           | 0.00±0.00                    |
| Cont                       | 1.39±0.50           | 1.39±0.50           | 0.00±0.00                    |

Exp=Experimental group; Cont=Control group, wks=weeks, MFT=Manual Function Test, FE=Forward elevation of the upper extremity, LE=Lateral elevation of the upper extremity, PO=Touching of the occiput with the palm, PD=Touching of the dorsum with the palm, GR=Grasping
normally takes place in the first month, and functional recovery progresses at a slower pace, occurring between 6 and 12 months after the stroke event\(^26\), although full recovery of the affected upper extremities is often a challenge due to laxity or stiffness, as well as reduced rotational capacity of the torso, which limits the mobility of other body parts or induces pain\(^8\). The most important factor in predicting a stroke patient’s recovery is the degree of initial paralysis\(^7\), and quick application of remedial measures is essential in ensuring the minimum amount of functional impairments for the patient and ultimately achieving recovery\(^29\). The severe and unstable conditions of the patients who enter the NSICU require intensive and collaborative care from various clinical departments, and introducing remedial treatments in the early stage of a stroke has been a challenge.

In this study, applying ROM exercise to immobile stroke patients in the experimental group, who were vulnerable to increased edema due to limited blood and lymph circulation, within 72 hours of their diagnosis resulted in a reduced level of edema as measured at 2 and 4 weeks. On the other hand, patients in the control group who started remedial exercise 2 weeks after their diagnosis showed a higher level of edema, which stayed in the high range even after the remedial exercise. This suggests the effectiveness of applying ROM exercise immediately after acute stroke diagnosis. This study observed that the circumference of the fingers decreased over the course of 4 weeks, which was longer than the 2-week duration used in a previous study by Tang et al. (2006) that proved ROM exercise to be effective, and so we recommend that the ROM exercise be continued for 4 weeks for more impact. According to the results of this study, the circumferences of the fingers, wrist, and elbow on the unaffected side in the experimental group patients decreased consistently, while those in the control group showed significant decreases in the second half of the study period, between weeks 2 and 4. Taking into consideration a previous study that concluded cerebrum lesions can affect the same side of the body, this indicates that not conducting exercise on the unaffected side affects the severity of edema\(^26\).

The ROM of the affected shoulder as measured by flexion, extension, abduction, pronation, and supination increased at 2 weeks in the experimental group, while the control group demonstrated no change. Further improvements were shown in the following 2 weeks between weeks 2 and 4 in the experimental group, while the control group showed some improvements in flexion, abduction, pronation, and supination but no change in extension. The experimental group showed significant improvements in the affected elbow’s flexion, extension, and supination, as well as in the flexion, extension, and ulnar and radial deviation of the affected wrist; the control group showed no difference between the pre- and post-test values. The ROM for the elbow and the wrist in the experimental group improved over the course of 4 weeks, while those in the control group started improving at 2 weeks. This suggests the necessity to start the ROM exercise early in the NSICU. Because the flexion of the shoulder and movements, such as shrugging, affect the recovery of manual functions\(^27\), a reduced range of supination increases the amount of shoulder pain. The increased stiffness of internal and external rotation reduces the ROM\(^8\), and the increased ROM due to the ROM exercise as demonstrated in this study is clinically significant.

The function of the upper extremities improved noticeably in the experimental group compared with the control group, and the difference was noted through the frontal elevation of the upper extremities. However, other categories helpful in understanding the functional recovery of the hand were either difficult to measure or showed no change. Based on the proximal-distal theory, which states that mobility of the arm enabled by adjustment of the shoulders leads to functional improvement of the elbow, wrist, and fingers\(^29\), consistent remedial exercise over a longer period of time and observation are needed. Because losing the function of the upper extremities affects the protection reaction and posture, and the older population in particular relies heavily on their upper extremities for balancing, recovery of the functional capabilities of the upper extremities is extremely important\(^28\).

The self-care skills observed in this study, especially eating and dressing oneself (top), showed significant improvement in the experimental group compared with the control group, confirming the results of a precedent study\(^3\) that concluded that early-stage remedial exercise were effective in improving ADL. ADL of an acute patient with hemiplegia demands a lot from the unaffected side, and improving the functions of both sides through exercise contributes greatly to improving the patient’s quality of life. The participants of this particular study showed low scores for ADL, owing to the fact that acute stroke patients with hemiplegia tend to rely on those around them for ADL at least partially if not entirely. This causes economic and emotional stress in those close to the acute stroke patients, which could be relieved by improving the patient’s upper extremity functions so that they can return to their daily lives.

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