Original Article

The immediate effects of rib cage joint mobilization and chest wall stretch on muscle tone and stiffness of respiratory muscles and chest expansion ability in patients with chronic stroke

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Abstract. [Purpose] The main purpose of this study was to identify the impact of rib cage joint mobilization and chest wall stretch on respiratory muscle tone and stiffness and chest expansion in stroke patients and to compare the effects of both interventions. [Subjects and Methods] Subjects were randomly assigned to a rib cage joint mobilization group (n=15) or a chest wall stretch group (n=15). Respiratory muscle tone and stiffness were measured using a myotonometer, and the chest expansion was gauged using a measuring tape. [Results] A significant difference was found on comparing the respiratory muscle tone and stiffness on the affected and sound side before intervention. Although both groups showed an increase in respiratory muscle tone and stiffness after intervention, no significant difference was found. A significant increase in chest expansion was observed; however, no significant difference was observed in the variations between the groups. [Conclusion] This study suggests that rib cage joint mobilization and chest wall stretch exercises can be used to increase chest expansion potential and respiratory muscle tone in patients with chronic stroke.

Key words: Rib cage joint mobilization, Chest wall stretching, Muscle tone

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INTRODUCTION

One of the common problems that hospitalized stroke patients have is more likely to be inspiration than expiration1). An inspiratory disorder is caused by respiratory muscle weakness2) on the affected side and rib cage contracture3). Interventions that increase rib cage mobility are necessary, as the increased rib cage movement is effective in enhancing pulmonary function, rib cage expansion, and respiratory muscle activation in stroke patients3).

Recent studies have objectively proved that stretch exercises and joint mobilization are efficient methods for improving respiratory function in stroke patients4, 5). However, even though joint mobilization and stretch exercises both increase respiratory muscle activation4, 6) and rib cage expansion, no comparison has been made between the two interventions. Since the measurement of respiratory function has only been made with regard to pulmonary function, respiratory muscle activity, and chest expansion4, 5), an analysis of respiratory muscle tone and stiffness by comparing unaffected and affected sides is needed.

In previous studies, most cases involved the consideration of stretching exercises that increase pulmonary function performed by stroke patients as compared with the control group3). Even though there are some studies comparing joint mobilization exercises with threshold inspiratory muscle training or respiratory muscle resistance exercise, the mobilization
exercises in the previous studies were combined with massage and applied to the entire rib cage. The joint mobilization exercises in this study, however, are characterized by the provision of vibration to a restricted area to induce the restoration of movement. The aim of this study was to investigate the immediate changes in respiratory muscle tone and stiffness and chest expansion by comparing rib cage joint mobilization and chest wall stretch.

SUBJECTS AND METHODS

This study involved 30 patients who had been diagnosed with stroke for 6 months or more, and who were admitted in A and B Hospital in Anyang City, Gyeonggi. Subjects included those who scored more than 24 points in the Korean mental status examination, who were at stage IV or above in the Brunnstrom stage, who were at stage II or below in the Modified Ashworth Scale (MAS), who had no orthopedic disease in the rib cage, and/or those who felt a firm end-feel in their hands when slowly bending their whole body over in a lateral position. Patients with a history of respiratory diseases or those who were considered to be unfit to participate in the study by their physicians were excluded. Following selection, the subjects were randomly divided into two groups: the rib cage joint mobilization (RCJM) group (n=15; 12 males and three females; seven right hemiplegia, eight left hemiplegia; mean ± SD: weight, 72.7 ± 2.8 kg, time since stroke 10.6 ± 0.9 months), and a chest wall stretch exercise (CWSE) group (n=15; 10 males and five females; four right hemiplegia, 11 left hemiplegia; mean ± SD: weight; 70.3 ± 1.5 kg; time since stroke 11.9 ± 3.1 months). In addition, this study was approved by the local ethics committee of Yong-In University, and the research process was conducted after written consent was obtained from the subjects.

The entire evaluation was overseen by one physiotherapist who had had more than 5 years of work experience. In order to measure the muscle tone and stiffness of the stroke patients, we used Myoton® PRO (Myoton AS, Estonia), the reliability and validity of which has been proved. The frequency (Hz) represents the duration of the effect of the testing end on the muscle and is therefore expressed as the muscle tone. Subjects underwent initial measurements after resting in the supine position for 20 minutes. This study is based on a previous study, which measured respiratory muscle activity, and aims to further measure the rectus abdominis muscles (RA), external oblique abdominal muscles (EO), upper trapezius muscles (UT), both large latissimus dorsi muscles (LD), and sternocleidomastoid muscles (SCM). The SCM, RA, and EO were measured in the supine position, whereas the LD and UT were measured in the prone position. First, the muscle belly of the muscles to be measured in the supine position was marked using a marker that is harmless to the human body. The measurement tool was placed vertically along the skin marker, and then the muscles were measured 5 times. These subsequent averages were used as data values. With the patient in the prone position, the measurements were taken in the same manner as the supine position. For this study, the post-test measurement was taken immediately after the intervention.

Subjects’ chest expansion ability was measured using a tape measure (Hoechstmass-Rollfix, Germany) while the subject breathed. While standing in an upright position, the subject placed their arms and legs in a comfortable manner. The upper chest expansion was measured horizontally along the chest using the fifth thoracic spinous processes as a basis, whereas the lower chest expansion was measured using the tenth thoracic spinous processes as a basis. Each patient’s chest circumference was measured at their maximum inspiration and expiration points, and the final measurement data were obtained by subtracting the minimum inspiration value from the maximum expiration value. The inter-rater reliability of this measurement method was found to be 0.99, which is close to 1.

In this study, both joint mobilization and stretch exercises were performed by a practitioner, who had taken the International Maitland Teachers’ Association level I course. The intervention was performed while checking the patient’s condition, and when there were complaints of pain. The rib cage joint mobilization procedure consisted of applying a posteroanterior unilateral costovertebral pressure, a posteroanterior unilateral costovertebral pressure, and a posteroanterior central vertebral pressure. Before the initiation of the intervention, the researcher applied posterior-anterior central vertebral pressure on the thoracic zygapophysial joint and costovertebral joint, and the joint with the most severe hypomobility was noted. Joint mobilization was applied to the joint with hypomobility, with the applied intensity being grade III. Each intervention was performed as three sets of 30 repetitions for a minute with 1-minute intermissions between the sets. The whole intervention took about 18 minutes to complete.

For the chest wall stretch exercise, two kinds of stretch exercises were used. For the first stretch exercise, the subjects were asked to lie in a supine position and inhale. While inhaling, the space between the third and eighth ribs was stretched downward using the index finger. When exhaling, the same method was used. In total, four kinds of stretch exercises were performed 10 times each, ensuring that the total intervention time did not extend beyond 10 minutes. The second stretch exercise, the trunk muscles stretch exercise, was performed as follows: (1) trunk rotation from a sitting position, (2) lateral bending from a side-lying position, and (3) trunk extension from a supine position. All of these were performed through active-assisted exercises. If needed, a pillow was used. The intervention was a repetition of 30 seconds of holding the position and 30 seconds of rest, and it lasted for a total of 10 minutes.

All collected data were statistically analyzed using Windows version SPSS 20.0 (IBM, Armonk, NY, USA). To test the normality of the subjects, the Shapiro-Wilk test was performed to confirm normal distribution, and homogeneity of variance was examined using an independent t-test and the χ² test. The differences in respiratory muscle tone and stiffness and chest expansion ability of paralyzed and non-paralyzed subjects were analyzed using a paired t-test. The difference between the intervention groups was determined using an independent samples t-test, and all statistical significance levels were set at p=0.05.
RESULTS

In the present study, a significant difference in the tone and stiffness of SCM, EO, UT, and LD was found between the injured and non-injured sides (p<0.05) (Table 1). For both groups, patient respiratory muscle tone and stiffness increased on average after intervention, but there was no significant difference (p>0.05). There was a significant increase in the extent of chest expansion (p<0.05). However, there was no significant difference between the two groups (p>0.05) (Table 2).

DISCUSSION

The subjects showed asymmetry in respiratory muscle tone and stiffness. In this present study, the subjects showed a significant increase in the tone and stiffness of SCM, EO, UT, and LD compared with the injured side before the intervention took place. These results are considered to be due to excessive respiration from the uninjured rib cage that occurred as the paralyzed side’s respiratory muscle was weakened.

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Table 1. Difference of between affect side and non-affect side of respiratory muscles

| Region                        | Variable              | Affected side   | Non-affected side |
|-------------------------------|-----------------------|-----------------|-------------------|
| Sternocleidomastoid muscle    | Muscle tone (Hz)      | 13.0 ± 0.2      | 13.7 ± 0.3*       |
|                               | Stiffness (N/m)       | 228.5 ± 4.7     | 242.6 ± 7.2*      |
| Rectus abdominis muscle       | Muscle tone (Hz)      | 12.0 ± 0.3      | 12.4 ± 0.3        |
|                               | Stiffness (N/m)       | 222.0 ± 5.5     | 227.6 ± 4.9       |
| External oblique abdominal muscle | Muscle tone (Hz)   | 12.6 ± 0.3      | 13.5 ± 0.3*       |
|                               | Stiffness (N/m)       | 229.7 ± 6.0     | 238.8 ± 7.6       |
| Upper trapezius muscle        | Muscle tone (Hz)      | 13.7 ± 0.5      | 14.2 ± 0.4*       |
|                               | Stiffness (N/m)       | 242.8 ± 7.2     | 261.1 ± 9.2*      |
| Latissimus dorsi muscle       | Muscle tone (Hz)      | 13.8 ± 0.4      | 14.9 ± 0.5*       |
|                               | Stiffness (N/m)       | 257.9 ± 8.9     | 284.2 ± 15.3*     |

Values are means ± standard error  
*Significant difference between of affected side and non-affected side on respiratory muscles (p<0.05)

Table 2. Change in muscle tone, stiffness of affected respiratory muscles and chest expansion in each group

| Region                        | Variable              | Group                  | Pre           | Post          |
|-------------------------------|-----------------------|------------------------|---------------|---------------|
| Sternocleidomastoid muscle    | Muscle tone (Hz)      | Ribcage joint mobilization | 12.9 ± 0.2   | 13.4 ± 0.3   |
|                               |                       | Chest wall stretch exercise | 13.2 ± 0.4   | 13.5 ± 0.4   |
|                               | Stiffness (N/m)       | Ribcage joint mobilization | 219.1 ± 5.1  | 229.6 ± 6.3  |
|                               |                       | Chest wall stretch exercise | 236.7 ± 8.0  | 243.4 ± 10.1 |
| Ractus abdominis muscle       | Muscle tone (Hz)      | Ribcage joint mobilization | 11.5 ± 0.3   | 12.1 ± 0.5   |
|                               |                       | Chest wall stretch exercise | 12.5 ± 0.5   | 12.9 ± 0.4   |
|                               | Stiffness (N/m)       | Ribcage joint mobilization | 210.8 ± 6.7  | 217.7 ± 9.8  |
|                               |                       | Chest wall stretch exercise | 231.9 ± 7.8  | 240.9 ± 8.9  |
| External oblique abdominal muscle | Muscle tone (Hz)   | Ribcage joint mobilization | 12.7 ± 0.5   | 13.2 ± 0.6   |
|                               |                       | Chest wall stretch exercise | 12.4 ± 0.3   | 12.7 ± 0.3   |
|                               | Stiffness (N/m)       | Ribcage joint mobilization | 231.8 ± 10.7 | 236.9 ± 12.7 |
|                               |                       | Chest wall stretch exercise | 227.8 ± 6.4  | 230.1 ± 7.2  |
| Upper trapezius muscle        | Muscle tone (Hz)      | Ribcage joint mobilization | 14.2 ± 0.8   | 15.2 ± 0.8   |
|                               |                       | Chest wall stretch exercise | 13.2 ± 0.5   | 13.9 ± 0.5   |
|                               | Stiffness (N/m)       | Ribcage joint mobilization | 256.4 ± 11.1 | 295.9 ± 23.3 |
|                               |                       | Chest wall stretch exercise | 230.9 ± 8.8  | 242.6 ± 11.5 |
| Latissimus dorsi muscle       | Muscle tone (Hz)      | Ribcage joint mobilization | 14.1 ± 0.7   | 14.3 ± 0.6   |
|                               |                       | Chest wall stretch exercise | 13.4 ± 0.4   | 13.9 ± 0.4   |
|                               | Stiffness (N/m)       | Ribcage joint mobilization | 268.7 ± 16.1 | 280.8 ± 22.6 |
|                               |                       | Chest wall stretch exercise | 247.6 ± 8.9  | 251.7 ± 8.8  |
| Upper chest expansion         | Ribcage joint mobilization | 1.3 ± 0.2       | 1.8 ± 0.2*     |
|                               |                       | Chest wall stretch exercise | 1.2 ± 0.1    | 1.5 ± 0.2*    |
| Lower chest expansion         | Ribcage joint mobilization | 2.2 ± 0.3       | 2.7 ± 0.3*     |
|                               |                       | Chest wall stretch exercise | 1.8 ± 0.2    | 2.2 ± 0.2*    |

Values are means ± standard error  
*Significant difference between before and after intervention in each group (p<0.05)
In the present study, both the RCJM group and the CSWE group showed a significant increase in the extension of chest expansion after intervention, and, while there were no significant differences in their muscle tone and stiffness, there was an improvement on average.

According to Wang et al.11), the increase in muscle tone and stiffness of respiratory muscles among paralyzed patients following respiration exercises was a positive change in their respiratory muscles. Park4) showed that there was an increase in chest expansion and respiratory muscle activity when rib cage joint mobilization was applied to stroke patients. The findings of Yilmaz Yelvar et al.12) support our findings, as they demonstrated that after frequency treatment was applied to patients with chronic obstructive pulmonary disease, the patients showed an increase in inspiratory and expiratory pressures, even if their rib cages had limitations. This is thought to be because of the repetitive motion of the joints and because the chemical or mechanical stimuli are removed9), thus improving the flexibility of the chest and increasing the muscle tone and stiffness of the respiratory muscles of the paralyzed area and also increasing the range of motions in the rib cage.

In a previous study, Rattes et al.5), showed that the pulmonary function and total chest capacity of 10 stroke patients increased after intervention with respiratory stretch exercises and that intercostal stretch applied to healthy subjects resulted in an increase in their parasternal activity9). Therefore, the increase in muscle length during stretching affects the force-length relationship13). Thus, it is possible to increase muscle tone and stiffness and the range of chest movements by increasing one’s force production capacity.

In a study by Kim et al.14), which compares stretching exercises and joint mobilization effects, patients with neck pain were used as subjects. Upon comparing the two intervention methods applied, results showed that the patients’ cervical range of motion significantly increased, but that there was no significant difference between the each groups. In this study, both methods resulted in a significant increase in chest expansion before and after the intervention. However, similar to the previous study, there was no significant difference between the two intervention methods in terms of respiratory muscle tone and stiffness and chest expansion ability.

This is thought to be because stroke patients experience a decrease in respiratory muscle tone and stiffness, muscle shortening, and joint contracture all at the same time15). Therefore, both methods were necessary to increase muscle tone and stiffness and chest expansion ability. In addition, there was no difference between these two intervention methods because of this reason.

In this study, we could not control the psychological factors affecting muscle tone. The effects were immediate, but the more long-term effects are yet to be seen. In future studies, it may be possible to see greater differences if the psychological factors affecting the subjects, and especially if both immediate and long-term effects, are taken into consideration.

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