The Effects of Complex Breath Exercise for Trunk Muscles Activation and Trunk Control in Persons with Chronic Stroke.

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Purpose The purpose of this study was to determine the effects of forced inspiration and forced inspiration and forced expiration exercise on stroke patients' trunk muscle activity, trunk control ability. ***Methods*** Twenty four patients with stroke were randomly assigned to a control group with physical therapy and a complex breath exercise as well. The complex breath exercise group received physical therapy for 30 minutes and complex breath exercise for 30 minutes and the control group received physical therapy 60 minutes. All of them conducted exercises 5 times per week for 6 weeks. Surface Electromyogram used to measure trunk muscle activity of paretic side. Trunk Impairment scale used to trunk control. ***Results*** The result of this study were as follows: Compare complex breath exercise group and control group showed a significantly difference in rectus abdominalis, external oblique, internal oblique (p<.001). Trunk control showed a significantly difference in complex breath exercise group (p<.001). ***Conclusion*** The result of this study suggest that complex breath exercise increase trunk muscle activity, trunk control and balance ability in paretic side. So, complex breath exercise is effective treatment of trunk stability for chronic stroke patients.

Key words Stroke, Breath Exercise, Muscle Activation, Trunk Control

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I. Introduction

Persons with Chronic Stroke is about 50–70% of affected individuals recover functional independence, and within 6 months, about 50% of these patients present hemiplegia/ hemiparesis.[1] Stroke is usually caused many neurological symptoms such as cognitive impairment, muscle weakness and loss of sensation in opposite side upper extremity and lower extremity from the damaged brain hemisphere[2], and stroke caused to serious limitations in physical activities as a disorder of motor function and sensory function[3]. Loss of motor control caused trunk asymmetry, abnormal alignment cause balance and coordination disability.[4] The hemiplegic patients of stroke appeared abnormal movements of the trunk particularly appear abnormal postures and movements for motor control.[5] Muscle strength and endurance of the trunk in order to maintain a variety of positions in the ADL is very important. In addition, abdominal and trunk muscles are relative in trunk stability and important to movement and posture control. Loss of selective movement in trunk muscles represents an instability for maintaining the upright position. In addition, there is a close relationship from those of the respiratory muscles for maintaining the posture. [6, 7] The effect of a stroke lesion in the respiratory system depends on the structures.[8] Respiratory muscle classify the inspiratory muscles and expiratory muscles. During usual inspiration, the diaphragm and intercostal muscle are the primary muscle that contract. During normal forced inspiration, an additional number of assessory muscles may contract along with pectoralis major, pectoralis minor, scalenes, sternocleidomastoid trapezius, erector spinae and serratus anterior. Usual expiration is passive and involves no muscular contraction. During normal forced expiration, the internal intercostal and the abdominal muscles contract.[9] In addition, the local muscles as transverse abdominis and internal oblique abdominis, multifidus, diaphragm is connected between the spinal segment to provide maintain posture control and stability of the spine, rectus abdominis and the external oblique abdominis, erector spinae generates a force in the global muscles involved in the trunk overall stability.[10] Diaphragm and transversus abdominis contributes to postural control with the breathing, before limbs appear moving diaphragm and transversus abdominis muscle activity.[11, 12] In addition, diaphragm is demanded with the adjacent muscle to the abdominal cavity whenever trunk unstable. The diaphragm and abdominal muscles contribute spinal stabilization by stiffening the lumbar spine through increased intra-abdominal pressure. Therefore, incoordination of the diaphragm and abdominal muscles may result in instability and dysfunction of the lumbar spine.[13] Many studies related to strokes and respiratory have been conducted with a view to reinforcing respiratory and choose the inspiration exercise intervention. There is a close relationship with respiratory muscles and trunk stabilizer muscles. Therefore, the purpose of this study was to determine the effects of forced inspiration and forced inspiration and forced expiration exercise on stroke patients' trunk muscle activity, trunk control ability.

II. Materials and Methods

1. Subjects

Study subjects was stroke patients who had suffered a stroke and were hospitalized and treated at the G hospital located in Cheonan City, from July 20 to October 16, 2015. The subjects of this study were 24 chronic stroke patients who had been diagnosed with stroke by computed tomography or magnetic resonance imaging (MRI), with a duration of at least six months after the onset of their stroke. The subjects of the study were selected from among patients without any particular history of pulmonary disease before the onset of stroke, and without combined injury such as congenital chest deformity, or rib fracture. A further criterion for inclusion was that all subjects had to score 24 points or higher on the mini mental state examination-Korean version score to ensure that they were able to understand and follow what the researcher instructed. All subject was randomly allocated to a complex breath exercise group (CBEG, n=12) or control group (CG, n=12).

2. Procedures

The experiment was conducted five times per week for six weeks. CBEG received ordinary physical therapy for 30 minutes consisting of joint mobilization exercise, muscular strengthening exercise, trunk stabilization exercise and complex breath exercise for 30 minutes. CG received ordinary physical therapy for 60 minutes consisting of joint mobilization exercise, muscular strengthening exercise and trunk stabilization exercise. There are intervention complex breath exercise. Complex breath exercise was combining the inspiration exercise and expiration exercise.

The subjects assumed a supine position while undergoing thoracic resistance exercise on the thoracic area. Briefly, the therapist places both hands on the sternum of the subject. Pressure is then applied from the sternum area, in a caudal and dorsal direction, in line with the patient's respiratory rhythm so that the subject can sufficiently breathe out during expiration, while in supine position. And the therapist places the hands on the lower rib area to reinforce. The therapist applies pressure in a caudal and medial direction in line with the patient's respiratory rhythm so that the subject can sufficiently breathe out during expiration, while in supine position. [14, 15]

Expiration training device uses a threshold PEP. In previous studies the training of the scale of the pressure threshold PEP between 10~20 cmH_2O was referred to the optimal settings to improve expiratory pressure, depending on the clinical recommended dose increased the strength by 2 cmH_2O week starting from 7 cmH_2O.[16, 17] Subjects were seated posture in the peak expiratory hip and knee flexion to be 90 degrees in a chair without a backrest were kept about 2-3 seconds. If a patient complained of fatigue or dizziness during the breathing exercise, subjects took a rest before restarting the exercise.

3. Measurement

As measurement equipment for the activation of the muscles, Delsys-Trigno Wireless EMG System(Trigno EMG Sensor, DelsysInc., Boston, MA, USA) was used. Electromyography was measured while the patients breathing in sitting position. Surface electrodes were attached to the RA(3 cm lateral to the umbilicus), the EO(15 cm lateral to the umbilicus), the IO(midway between the anterior iliac spine and symphysis pubis, above the inguinal ligament) and the MF(caudal tip posterior spina iliaca superior to the interspace between L1 and L2 interspace at the level of L5 spinous process). For electrode analysis of trunk muscles, muscle contraction of specific motions was assumed as reference voluntary contraction(RVC) and based on this, standardization was made(%RVC method) and electrode values on the effect of breath exercise were observed using integrated EMG. Subjects were measured at 90 degree sitting position of the hip and knee bent in a chair without a backrest. To measure the trunk muscles researcher, "After exhale deeply, keep your mouth shut and hold breath for 5 seconds." to the person that was conducted gives a relief. Trunk control ability was measured using the trunk impairment scale (TIS).[18]

4. Data Analysis

Statistical processing of the data was conducted using SPSS ver. 20.0, and descriptive statistics was used to analyze the subjects general characteristics. The CBEG and CG were compared using ANCOVAs that processed the results of prior measurements of the individual groups as covariates, with the statistical significance(α) set to .05.

III. Results

Table 1 shows the general characteristics of the study subjects. There were no significant differences in any of the characteristics between the CBEG and CG groups ($p > 0.05$). Table 2 shows group comparisons of paretic side trunk muscles activation. CBEG and CG showed a significantly difference in RA, EA, IO ($p < 0.001$), But there was no significant in MF ($p > 0.05$). Table 3 shows group comparisons of trunk control ability. CBEG and CG showed a significantly difference in TIS ($p < 0.001$).

IV. Discussion

In this study, the effects of complex breath exercise on trunk muscles activation and trunk control ability in chronic stroke patients were investigated. The subjects were 24 patients who had been hospitalized after being diagnosed with hemiplegia caused by chronic stroke. This study was conducted for six weeks using EMG and TIS for evaluation.

To examine the effects of complex breath exercise on the paretic side trunk muscles of chronic stroke patients, the paretic side trunk muscles activation was compared after intervention. The comparison between CBEG and CG showed significant differences in RA, EO, and IO, but no significant difference in MF. The effects on trunk control ability also showed significant difference between CBEG and CG after intervention. The sensory and motor impairment of trunk interferes with the functional performance after stroke. Contrary to common belief, the trunk muscles are impaired on both sides of the body in persons with stroke.[19] There are postural, muscle tonus and motor control abnormalities that compromise voluntary movement and trunk muscle synergy.[20] A reduction of respiratory muscles strength and thoracic cage movement leads to decreased coordination, and affects the normal postural control of trunk muscles and respiratory muscles.[21, 22] The maximal respiratory pressure which indicates respiratory muscles strength is divided into maximal expiratory pressure (MEP) and maximal inspiratory pressure (MIP), and MEP is represented by the force of internal intercostal and abdominal muscles that are mobilized during forced expiration. This MEP is closely associated with trunk control ability.[8] Inspiratory muscles are skeletal muscles morphologically or functionally. As with other skeletal muscles, if they are trained with proper physiological load, MIP and endurance are improved due to the enhanced strength of inspiratory muscles.[23, 24] Lim & Shin[25] reported that feedback respiratory exercise led to significant improvement of pulmonary function in chronic stroke patients. Han et al.[26] applied feedback breathing exercise to stroke patients which resulted in a significant difference between assessory respiratory muscles and abdominal muscles, which is identical to the result of this study. Muscle activation seems to have increased as complex breath exercise had positive effect on the paretic side abdominals of stroke patients. As it was revealed by Hodges and Gandevia[12], trunk control ability is closely related to diaphragm and abdominals. Repeated postural changes contract the diaphragm and the more difficult the task is, the greater the contraction becomes. The results indicate that activity of phrenic motoneurones is organised such that it contributes to both posture and respiration during a task which repetitively challenges trunk posture. IO is a local muscle that connects between spinal segments and helps maintain posture by providing fine adjustments and stability of the spine. RA and EO are global muscles which generate force and are involved in the overall trunk stability.[10] Therefore, an increase of the muscle activity of diaphragm and abdominals improves trunk stability and trunk control ability. In a study on the correlations among respiratory muscles, pulmonary function, and trunk control in stroke patients, Jandt et al.[8] reported that the correlations be-

Table 1. General characteristics of each group

	CBG (n=12)	CG (n=12)	*p*
Sex(male/female)	8/4	9/3	.653
Paretic side (right/left)	6/6	5/7	.682
Age(yr)	57.67±11.99	59.75±11.17	.664
Height(cm)	163.75±10.34	168.50±8.03	.256
Weight(kg)	62.67±11.95	65.50±12.73	.580
Time since stroke(mon.)	20.83±13.88	24.17±15.86	.589

Note. values are mean±S.D

Table 2. Comparisons of paretic trunk muscles %RVC after complex breathing exercise group and control group

		CBG (n=12)	CG (n=12)	*F*	*p*
RA	Pre	101.53±6.70	99.75±4.79	131.972	.001**
	Post	133.16±7.89	105.07±4.69		
EO	Pre	102.54±5.31	100.27±4.10	118.077	.001**
	Post	131.98±10.93	105.43±4.10		
IO	Pre	104.76±5.21	99.82±3.21	125.206	.001**
	Post	135.69±9.11	105.74±4.04		
MF	Pre	105.70±9.67	100.32±4.76	1.014	.325
	Post	111.31±10.27	104.81±5.80		

Note. Values are mean ± standard deviation. *$p<.05$, **$p<.001$

Table 3. Comparisons of trunk impairment scale between complex breathing exercise groups and control groups

	CBG (n=12)	CG (n=12)	*F*	*p*
Pre	13.83±1.19	12.92±2.87	19.486	.001**
Post	16.50±1.45	13.17±3.10		

Note. Values are mean ± standard deviation. *$p<.05$, **$p<.001$

tween TIS and MEP was consistent and statistically significant. The correlation between the TIS and MIP was consistent but not statistically significant. However given that the value obtained was very close to the one that would be considered as statistically significant. Abdominals perform trunk stability together with axial muscle and diaphragm.[27] Therefore, when the trunk need to be stabilized, a functional change of the respiratory muscles requires coordination between the tonic and phasic of the diaphragm and transverse abdominis, and promotes the coordination reaction of CNS between respiration and trunk movements.[12, 27] Song and Park[28] applied chest resistance exercise to the stroke group and a significant difference in TIS was observed, which agrees with the result of this study. The reason for this seems to be that the respiratory muscles are closely associated with the postural control of the trunk[8], and the increased muscle activity of the trunk muscles by complex breath exercise improved trunk stability and trunk control ability. Proper resistance during breathing exercise was found to be more effective to the muscle activity and trunk control ability of the abdominal muscles. Trunk muscles are very important clinically for the trunk control ability, balance ability, and gait improvement. Furthermore, respiratory muscles are closely related to the trunk muscles during ordinary or forced respirations.[6] This study has a few limitations in interpretation of the results. First, it is difficult to generalize the results to all stroke patients because the number of subjects is small. Second, the correlation between breathing exercise and trunk stability could not be confirmed any more because other trunk muscles could not be measured. Third, due to the nature of this study, it is difficult to determine whether the comparative treatment effect of the research group was the effect of exercise intensity and complex breath exercise. Fourth, persistence effect could not be confirmed because the study period was only six weeks. Therefore, further studies are required in the future with more subjects on the correlation between other trunk muscles and breathing and on the persistence effects of exercise.

V. Conclusion

This study was conducted to investigate the effects of complex breath exercise on the trunk muscle activity and trunk control ability of chronic stroke patients. In the comparison between CBEG and CG, the trunk muscle activity showed significant differences only in RA, EO, and IO, trunk control ability were significant differences. The results of this study will be helpful for setting treatment programs for the improvement of trunk muscle activity and balance in stroke patients.

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