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Original Article

The immediate effect of diaphragm taping with breathing exercise on muscle tone and stiffness of respiratory muscles and SpO_2 in stroke patient

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Abstract. [Purpose] This study aimed to examine the immediate effects of diaphragm taping with breathing exercise on the tone and stiffness in the respiratory muscles of patient with stroke. [Subjects and Methods] A total of 28 subjects, 14 in the diaphragm taping with breathing exercise group and 14 in the breathing exercise group, were administered respective intervention methods. Subsequently, the muscle tone and stiffness in upper trapezius, scalene, external oblique abdominal and ractus abdominis muscle of both the respiratory muscles were measured. [Results] The comparison of respiratory muscles on the affected and non-affected sides in stroke patients showed statistically significant declines in the muscle tone and stiffness of all measured muscles but not in the stiffness of the external oblique abdominal muscle and rectus abdominis muscles. After intervention, the diaphragm taping with breathing exercise group exhibited statistically significant increases in the muscle tone of all measured muscles and in the stiffness of the upper trapezius and scalene muscles, and statistically significant declines in the saturation of peripheral oxygen. However, the breathing exercise group showed statistically significant increases only in the muscle tone of the upper trapezius and external oblique abdominal muscles. [Conclusion] This study demonstrated that diaphragm taping with breathing exercise had positive effects of immediately increasing the muscles tone and stiffness in the respiratory muscles.

Key words: Affected respiratory muscle, Muscle tone, SpO_2

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INTRODUCTION

Breathing after a stroke causes changes in the volume of the rib cage, chest wall, and abdomen on the affected side[1)] and an elevation of the diaphragm[2)]. Because physical movements activate the respiratory muscles[3)] and consume oxygen in the peripheral region[2)], pulmonary physical therapy should improve the function of paralyzed respiratory muscles in stroke patients and maintain appropriate levels of oxygen within the body during exercise. The Saturation of Peripheral Oxygen (SpO_2) indicates the concentration of hemoglobin combined with oxygen in the blood in terms of percentage (%) and is influenced by motor performance[4)]. Recent studies have objectively proved that pulmonary therapeutic exercises are effective in improving stroke patients' respiratory function and respiratory muscle activity[3, 5, 6)]. However, only a limited number of studies have investigated improvements in the muscle tone and stiffness of respiratory muscles in stroke patients. Taping, which was selected as an intervention in this study, is well known as an effective therapeutic method for peripheral nerve facilitation, muscle balance, and pain control[7)].

Therefore, the intent of this study was to determine the effects of pulmonary therapeutic exercises on stroke patients by

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identifying the effects of diaphragm taping with breathing exercise on the immediate improvement of the muscle tone and stiffness of respiratory muscles and SpO_2 in stroke patients.

SUBJECTS AND METHODS

The study subjects were strokes patients hospitalized at a geriatric hospital in Gyeonggi-do, South Korea. They were diagnosed with stroke using computed tomography (CT) or magnetic resonance imaging (MRI). All subjects had normal cognitive functions with 24 points or above on the Korean version of the Mini-Mental State Examination (K-MMSE)[8], scored grade 2 or above on the Modified Ashworth Scale, and had no muscular disorders. Those with spinal orthoses or corsets, tracheostomy tubes, or nasogastric tubes were excluded. The subjects were randomly divided into the taping with breathing exercise group (TBEG) (N=14, mean ± SD: age, 68.3 ± 7.9 years; 10 males and 4 females; height, 167.1 ± 7.8 cm; weight, 68.7 ± 6.7 kg; K-MMSE, 26.3 ± 1.4 points; onset, 12.3 ± 4.4 months) and the breathing exercise only group (BEG) (N=14, mean ± SD: age, 66.3 ± 7.7 years; 12 males 12 and 2 females; height, 167.5 ± 7.6 cm; weight, 71.4 ± 7.5 kg; K-MMSE, 26.0 ± 1.5 score; Onset, 12.8 ± 3.7 month). This study was approved by the Institutional Review Board of Howon University. The purpose and intent of the study were explained to all subjects, and the experiment was conducted on those who agreed to participate.

Diaphragm taping was applied in the TBEG using an elastic tape 5 cm in width (Kinesiology 3NS Tape, TS, South Korea). The length of the tape was measured to fit the left and right parts of each subject's body. The lower ribs were wrapped with the tape starting from the thoracic spine, and the length of the tape up to the tip of sternum was measured. The tape was then cut into three-fourths of its total measured length and extended and attached to the same region. The tape was attached during each subject's maximum voluntary expiration in an upright sitting position. Finally, vertical tape was attached to fix the base of the two pieces of tape in the thoracic region to which tape was attached earlier[7].

All subjects relaxed in a supine position for 30 minutes and then performed diaphragm resistance exercise during inspiration and pursed-lip exercise during expiration in a sitting position for 30 minutes[5]. When a patient complained of symptoms such as dizziness and fatigue during the breathing exercise, he/she was allowed to take a break and then resume. The muscle tone and stiffness of the respiratory muscles and SpO_2 were measured for all subjects. The first measurement was taken after the subjects had relaxed for 20 minutes, and the post-intervention measurement was taken immediately after the intervention. The muscle tone and stiffness of respiratory muscles was measured using non-invasive Myoton®PRO (MyotonAS, Estonia) equipment, the reliability of which has been verified[9]. The muscles measured were the upper trapezius muscle (UT), scalene muscle (SM), external oblique abdominal muscle (EO), and rectus abdominis muscle (RA) on the affected and non-affected sides. The common feature of these muscles is that they are all involved in breathing[10]. Skin markers were symmetrically attached over the SM, EO, and RA muscles on both sides when the subjects were in a supine position and over the UT muscles on both sides when they were in a prone position. The measurement device was placed perpendicular to the skin markers to take measurements. The mean value of two measurements was used. The SpO_2 was measured while the subjects were in a supine position using a fingertip pulse oximeter (Beijing Choice Electronic Technology Co., Ltd., China) that had been self-attached to their affected index finger. Taping and breathing exercise were implemented by a licensed physical therapist. The statistics software program SPSS 21 for Windows was used to analyze the collected data. A Wilcoxon signed-rank test was performed to compare differences in the muscle tone and stiffness of respiratory muscles on the affected and non-affected sides and differences in the effects of intervention within each group. A Mann-Whitney test was used to compare differences in the effects of intervention between the two groups; the statistical significance level was set at α=0.05.

RESULTS

The comparison of respiratory muscles on the affected and non-affected sides in stroke patients showed statistically significant declines in the muscle tone and stiffness of all measured muscles but not in the stiffness of the EO and RA muscles ($p<0.05$) (Table 1). After intervention, both groups showed an overall increase in muscle tone and in stiffness of the affected respiratory muscles. The TBEG exhibited statistically significant increases in the muscle tone of the affected UT SM, EO, and RA muscles and in the stiffness of the affected UT muscles. The BEG showed statistically significant increases only in the muscle tone of the affected UT and EO muscles ($p<0.05$). However, there were no statistically significant differences in the effects of intervention between the groups. While the TBEG showed statistically significant declines in SpO_2 ($p<0.05$), no differences were found between the groups (Table 2).

DISCUSSION

When the subjects were measured before the experiment, the respiratory muscles on the affected side showed statistically significant lower levels of muscle tone and stiffness except for the RA and EO muscles when compared with the respiratory muscles on the non-affected side. In other words, the abnormal muscle tone and stiffness shown in the extremity muscles of stroke patients[9, 11] were similar to the tone and stiffness of their respiratory muscles. An electromyogram (EMG) study of the respiratory muscles of strokes patients[3] showed lower levels of respiratory muscle activity on the affected side, similar to the

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

Region	Variable	Affected side	Non-affected side
Upper trapezius muscle	Muscle tone (Hz)	13.3 ± 0.3	14.2 ± 0.4*
	Stiffness (N/m)	237.4 ± 7.2	265.6 ± 13.9*
Scalene muscle	Muscle tone (Hz)	13.1 ± 0.2	13.7 ± 0.2*
	Stiffness (N/m)	219.8 ± 6.0	242.3± 8.4*
External oblique abdominal muscle	Muscle tone (Hz)	12.2 ± 0.3	12.9 ± 0.3*
	Stiffness (N/m)	217.8 ± 6.2	222.3 ± 8.4
Ractus abdominis muscle	Muscle tone (Hz)	11.7 ± 0.2	12.3 ± 0.2*
	Stiffness (N/m)	215.7 ± 4.2	220.5 ± 5.1

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 SpO_2 in each group

Region	Variable	Group	Pre	Post
Upper trapezius muscle	Muscle tone (Hz)	taping with breathing exercise	13.2 ± 0.5	13.6 ± 0.5*
		breathing exercise	13.5 ± 0.5	14.4 ± 0.5*
	Stiffness (N/m)	taping with breathing exercise	229.0 ± 7.6	248.4 ± 11.6*
		breathing exercise	245.8 ± 12.1	258.2 ± 14.0
Scalene muscle	Muscle tone (Hz)	taping with breathing exercise	12.8 ± 0.2	13.4 ± 0.3*
		breathing exercise	13.5 ± 0.3	13.9 ± 0.4
	Stiffness (N/m)	taping with breathing exercise	214.3 ± 6.4	225.4 ± 7.1
		breathing exercise	225.2 ± 10.3	237.0 ± 12.8
External oblique abdominal muscle	Muscle tone (Hz)	taping with breathing exercise	12.1 ± 0.5	12.4 ± 0.5*
		breathing exercise	12.3 ± 0.4	12.8 ± 0.4*
	Stiffness (N/m)	taping with breathing exercise	214.5 ± 8.8	224.6 ± 10.3
		breathing exercise	221.14 ± 9.0	228.6 ± 9.5
Ractus abdominis muscle	Muscle tone (Hz)	taping with breathing exercise	11.8 ± 0.3	12.5 ± 0.5*
		breathing exercise	11.6 ± 0.3	12.0 ± 0.5
	Stiffness (N/m)	taping with breathing exercise	221.0 ± 6.5	229.4 ± 8.3
		breathing exercise	210.3 ± 5.2	220.6 ± 8.3
Saturation of peripheral oxygen		taping with breathing exercise	97.1 ± 0.2	96.2 ± 0.3*
		breathing exercise	97.4 ± 0.2	97.0 ± 0.2

Values are means ± standard error
*Significant difference between before and after intervention in each group ($p<0.05$)

findings of the present study. The results of this study may be important basic data that quantitatively show decreased muscle tone and stiffness in the affected respiratory muscles of stroke patients.

After each intervention, the TBEG showed statistically significant increases in the muscle tone of the affected UT, SM, EO, and RA muscles and in the stiffness of the affected UT muscles, whereas the BEG exhibited statistically significant increases in the muscle tone of the affected UT and EO muscles. However, there were no statistically significant differences in the effects of intervention between the two groups. Breathing exercise are effective for increasing the muscle activity of the affected UT and EU muscles in stroke patients[3]. Because this study confirmed only immediate intervention effects, there could be no differences between the groups. However, diaphragm taping combined with breathing exercise are highly effective in improving the muscle tone and stiffness of many respiratory muscles. In particular, the diaphragm can act as an inspiratory agonist through its contraction, which increases the superior-inferior diameter of the rib cage[10]. In this study, the specific extending and attaching of tape to this muscle may have increased inspiratory resistance, thereby inducing the involvement of more respiratory muscles during breathing exercis. A previous EMG study[3] supports the results of the present study, which is that the muscle activity of the affected UT and EO muscles in stroke patients increased after breathing exercise. However, given the possibility that diaphragm taping could be ineffective in improving respiratory strength[12], it is necessary to confirm the correlation between the muscle tone and stiffness of respiratory muscles and increases in respiratory strength through continuous research.

In addition, this study confirmed changes in SpO_2 after each intervention. The mean SpO_2 of strokes patients who had been hospitalized within 72 hours after a stroke was 96 ± 1%[13]. In this study, both groups showed a mean SpO_2 of around 97% at the initial measurement. The SpO_2 in the peripheral region decreases due to physical activity[4]. In this study, while both groups showed declines in the mean value of SpO_2 after intervention, only the TBEG showed a statistically significant decline. The results suggest that stroke patients should get plenty of rest to recover the SpO_2 in the peripheral region after diaphragm taping combined with breathing exercises. However, the limitation of this study is that its findings could not be compared with those of other studies due to a lack of previous studies on the muscle tone and stiffness of respiratory muscles in stroke patients. This study quantitatively showed declines in the muscle tone and stiffness of the affected respiratory muscles in stroke patients and recommends the use of diaphragm taping with breathing exercises to improve the tone and stiffness of these muscles.

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