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Original Article

Effects of expiratory muscle strength training on swallowing function in acute stroke patients with dysphagia

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Abstract. [Purpose] This study was conducted to identify the effects of expiratory muscle strength training on swallowing function in acute stroke patients with dysphagia. [Subjects and Methods] A total of 18 stroke patients with dysphagia were enrolled in the study. All participants were randomly assigned to either an experimental group (n=9) or a control group (n=9). All participants performed traditional-swallowing rehabilitation therapy in 30-minute sessions five times a week for four weeks; however, only the experimental group received expiratory muscle strength training. [Results] Both groups showed significant improvements after mediation. When compared with the control group, the functional dysphagia scale, vallecular residue, and penetration-aspiration scale were significantly improved in the experimental group. [Conclusion] Expiratory muscle strength training is an effective intervention for impaired swallowing function in acute strike patients with dysphagia.

Key words: Dysphagia, Expiratory muscle strength training, Stroke

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INTRODUCTION

Stroke is known to be a common cause of neurological diseases and disorders that cause swallowing, with incidence of swallowing disorders after stroke reportedly being as high as 30–50%[1, 2)]. Swallowing disorders due to stroke increase the risk of death due to complications such as aspiration pneumonia, malnutrition, and dehydration[3)]. Tracheal aspirations are commonly found in swallowing disorders; therefore, early prognosis appropriate treatments are important[4)].

Respiratory and swallowing occur by several anatomical structures and provide important functions associated with airway protection, such as coughing and swallowing action. These airway-protective actions are initiated by a signal that passes from the medulla oblongata to the pharynx, larynx, and trachea, and the receptors of the agency signal to training start by communicating and share the brainstem network called the behavior control assemblies (BCAs)[5)]. Stroke is often accompanied by a central diaphragmatic dysfunction, with movement disorders caused by stroke imposing limitations on diaphragmatic motion, which leads to decreased lung volume[6)]. In a previous study evaluating the risk of tracheal aspiration

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through a quantitative measure of voluntary cough, the maximal expiratory volume during inspiratory and expiratory airway suction in stroke with aspiration was reported to be lower than in the normal group[7]. As such, the maximum expiratory volume in patients with swallowing disorders is closely related to tracheal aspiration, which is often used as an indicator to predict swallowing disorder[8].

Expiratory muscle strength training (EMST) has consistently been reported as a remedial approach to swallowing treatment that strengthen muscles associated with swallowing by exhalation through the oral[9, 11]. The suprahyoid muscle causes the anterior-superior movement of the hyoid bone in the swallowing process and facilitates airway protection and normal swallowing during opening of the cricopharyngeal muscle[10]. EMST is a strength training method that employs resistance and it is known to effectively improve activation of suprahyoid muscles and movement of the hyoid bone[11, 12]. Wheeler et al. reported that EMST is an effective way to induce suprahyoid muscle activation through surface surface electromyography (sEMG)[11], which is reportedly effective in patients with swallowing disorders caused by decreased movement of the hyoid bone. EMST also has been reported as an effective method of suprahyoid muscle activation in Huntington's disease[13].

Although EMST is a potential remedial approach for swallowing disorder, it has only been investigated in the elderly and in patients with Parkinson's disease and Huntington's disease[11–13, 20], while its effects in stroke patients have yet to be evaluated. Therefore, in this study, acute stroke patients with dysphagia were monitored and examined to determine the effects of EMST. The specific purpose of this study was to identify the effects of EMST on swallowing in acute stroke patients with dysphagia.

SUBJECTS AND METHODS

This study included 18 stroke patients with dysphagia and was performed at I Hospital in Korea from 2014–2015. Participant selection criteria were as follows: (1) onset of no more than 1 month, (2) the person with swallowing disorder of pharyngeal stage through videofluoroscopic swallowing study (VFSS), such as aspiration, invasion or residues of pharyngeal stage, (3) no oral stage problems, such as mastication and oral facial muscle movement, (4) MMSE of more than 24, (5) no specific medical problems, including respirational problems. The general characteristics of the subjects are summarized in Table 1. Exclusion criteria were as follows: (1) person without the appropriate lips closed, (2) significant facial paralysis, (3) tracheostomy and percutaneous endoscopic gastrostomy, (4) hypertension. All of the protocols used in this study were approved by Gachon University. Before participation, the procedures, risks, and benefits were explained and all participants gave their informed consent. The participants' rights were protected according to the guidelines of the Gachon University.

All participants were randomly assigned to either an experimental group (n=9) or a control group (n=9). All participants performed traditional swallowing rehabilitation therapy in 30 minute sessions five times a week for four weeks. Expiratory muscle strength training was only provided to the experimental group in 30 minute sessions. Traditional swallowing treatment was composed of orofacial exercises, thermal-tactile stimulation, the Mendelson maneuver, effortful swallow, and supraglottic maneuver. All swallowing treatments were carried out by the responsible therapists.

The experimental group was trained using the EMST 150 (Aspire Products LLC., USA). First, patients were provided with a mouthpiece to blow into, after which the nasal cavity was closed using forceps. The personal maximal expiratory pressure (MEP) was then measured using a manometer. Wheeler et al. were trained with a threshold value of 70%, it based on the personal MEP[11]. The training consisted of taking a deep breath and biting a mouthpiece, during which time the patient was told to blow faster and stronger. Each patient received seven trainings per session, five times a week for four weeks. Breaks of 30 seconds were provided after one session.

To evaluate the swallowing function of patients with dysphagia, functional dysphagia scale (FDS), penetration-aspiration scale (PAS), vallecular residue (VR), and pyriform sinuses residue (PR) were assessed. The evaluation was conducted by an occupational therapist with 5 years of experience with swallowing rehabilitation.

Functional dysphagia scale (FDS) is a quantification of the degree of swallowing disorder, and testing to determine the effect of swallowing disorders quantitatively. A score of 0 was considered normal, while a score of 100 indicated the greatest severity. The inter-rater reliability of FDS (r=0.59) was also estimated[14].

Table 1. General characteristics of both groups

	Experimental group (n=9)	Control group (n=9)
Gender (male/female)	6/3	6/3
Age (years)	63.0 ± 5.8	63.1 ± 5.2
Stroke type (ischemic/hemorrhagic)	6/3	7/2
Affected side (left/right)	4/5	5/4
Onset duration (days)	21.4 ± 5.1	21.1 ± 4.0
MMSE	25.9 ± 2.5	26.4 ± 2.2

All variables are expressed mean ± standard deviation (SD). MMSE: mini mental state examination

The penetration-aspiration scale (PAS) was divided into eight stages depending on laryngeal penetration and trachea aspiration based on the vocal fold, with a higher stage indicating increased severity of aspiration[15)]. Also PAS after swallowing the food, the score is determined by the presence or absence of invasion or aspiration of food comes out through coughing. The inter-rater reliability of the PAS was 0.911[5)]. Vallecular and pyriform sinuses residue was divided into 0–3 grades, with higher grades indicating greater swallowing dysfunction. Specifically, Grade 0 indicating no residue, grade 1 indicated 25% or less, grade 2 indicated 25–50%, and grade 3 was more than 50%[16)].

All statistical analyses were performed using SPSS ver. 18.0. The differences between before and after intervention were compared with Wilcoxon signed-rank tests and differences within a group before and baseline score, change score of dependent variable of were tested using the Mann-Whitney U test. A $p<0.05$ was considered to indicate significance for all analyses.

RESULTS

General characteristics of both groups are shown in Table 1. Comparison of swallowing function within and between two groups is shown in Table 2. In the both experimental and control groups, significant improvement was observed in all variables ($p<0.05$), except for PR in the control group. In addition, experimental group showed great improvement than the control group in the FDS, VR and PAS ($p<0.05$).

DISCUSSION

This study was conducted to verify the effects of EMST on swallowing function in acute stroke patients. The experimental group showed a significant improvement in all evaluated factors, while the control group showed a significant improvement in all factors except pyriform sinuses residue. Comparison between groups revealed significant improvements in the FDS, VR, and PAS in the experimental group relative to the control group. These results provide evidence that EMST improves the swallowing function of patients with acute stroke.

In this study, the resistance level of EMST was 70%. Yoon et al. reported laryngeal lift and pharyngeal residue and a significant improvement in the pharyngeal transit time of food when applying 75% EMST resistance[17)]. These findings are consistent with the decreased vallecular residue observed in the present study. In this study, pyriform sinuses residue did not differ between groups. It is believed that the pyriform sinuses residue is related to upper esophageal sphincter opening, which is caused by a hyolaryngeal excursion to pull forward the hyoid bone and posterior contraction of the longitudinal pharyngeal muscle[18)]. However, this study did not measure changes in the upper esophageal sphincter opening.

In this study, intervention of EMST was carried out for four weeks. Pitts et al. was reported reduced aspiration applied to Parkinson's patients over a four-week EMST[19)], while Troche et al. reported a significant reduction in aspiration following EMST for four weeks[20)]. Similarly, the present study confirmed the effectiveness of EMST for four weeks at reducing aspiration and vallecular residue, as well as improving FDS, which is similar to the results of previous studies.

Reduced respiratory function is commonly observed in stroke patients[21)]. Thus, acute stroke patients in need of intensive rehabilitation will be feel fatigue easily during aerobic exercise. Moreover, problems due to fatigue will have adverse effects on quality of life and interfere with functional recovery. Accordingly, EMST training has the potential to improve respiratory function, as well as swallowing disorders, thereby improving overall treatment of stroke patients.

It should be noted that this study had several limitations. Specifically, it targeted only 18 stroke patients that met the selection criteria. Moreover, the total study did not evaluate a long period of time. Accordingly, future long-term studies of more patients are needed. In conclusion, the present study was conducted to evaluate the effects of EMST intended for patients with acute stroke on swallowing. The results revealed that EMST may have a positive effect on the swallowing of acute stroke patients.

Table 2. Comparison of swallowing function within and between two groups

	Experimental group (n=9)			Control group (n=9)		
	Before	After 4-weeks	Changes	Before	After 4-weeks	Changes
FDS Total	28.22 ± 5.33	18.44 ± 5.64**	−9.78 ± 2.73†	27.56 ± 5.64	22.00 ± 6.00*	−5.56 ± 4.22
VR	1.44 ± 0.53	0.33 ± 0.50**	−1.11 ± 0.33†	1.67 ± 0.71	1.11 ± 0.60*	−0.56 ± 0.53
PR	1.11 ± 0.60	0.56 ± 0.53*	−0.56 ± 0.53	1.11 ± 0.60	0.89 ± 0.60	−0.22 ± 0.44
PAS	4.78 ± 1.56	2.11 ± 1.27**	−2.67 ± 0.87†	5.00 ± 1.32	3.89 ± 1.27*	−1.11 ± 1.05

All values are the mean ± standard deviation (SD). FDS: functional dysphagia scale; VR: vallecular residue; PR: pyriform sinuses residue; PAS: penetration-aspiration scale
*$p<0.05$, **$p<0.01$
†Significant difference between groups ($p<0.05$)

Conflict of interest

The authors declare no conflict of interest.

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