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Original Article

The correlation of respiratory muscle strength and cough capacity in stroke patients

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Abstract. [Purpose] The purpose of this study was to investigate the correlation between respiratory muscle strength and cough capacity in stroke patients. [Subjects and Methods] Forty-two stroke patients were assigned to 2 different groups (intervention group=21, control group=21). Both groups participated in a conventional stroke rehabilitation program, with the intervention group also receiving respiratory muscle training for 20 to 30 minutes a day, 3 times a week for 8 weeks. Respiratory muscle strength (maximal inspiratory pressure, maximal expiratory pressure), forced vital capacity, and cough capacity were measured. [Results] The intervention group showed significant increases in maximal inspiratory pressure, maximal expiratory pressure, forced vital capacity, and cough capacity. The change in maximal inspiratory pressure, maximal expiratory pressure, and forced vital capacity showed a significant correlation with cough capacity, with maximal expiratory pressure showing the highest correlation. [Conclusion] The present study showed that the increase in maximal expiratory pressure plays an important role in improving the cough capacity of stroke patients.

Key words: Respiratory muscle strength, Cough capacity, Stroke

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INTRODUCTION

Respiratory dysfunction occurs after a stroke since forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1), and peak expiratory flow (PEF) are reduced due to the damage in diaphragmatic and respiratory muscles caused by the stroke[1, 2)].

Stroke subjects show reduced maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) when compared to healthy age-matched subjects[3)]. In addition to their importance for ventilation, inspiratory and expiratory muscles are also necessary to maintain upper airway patency through an efficient cough mechanism[4)]. However, since aging and neurological damage weaken the respiratory muscles in chronic stroke patients older than 60, patients cannot cough efficiently, and the prevalence of aspiration and chest infections increases[5–7)]. In order to improve their function, training of the damaged respiratory muscles is necessary[2, 8, 9)]. Respiratory muscle training can improve the FVC, MIP, MEP, and PEF in stroke patients[10)].

Cough consists of the following 3 phases: inhalation, forced exhalation against a closed glottis, and violent release of air from the lungs following the opening of the glottis[11)]. Expiratory muscle function is crucial for effective cough, but inspiratory muscle strength is also important since it is necessary to gain sufficient lung volume before expiratory muscle contraction[4)]. However, the relationship between increases in respiratory muscle strength and increases in cough capacity in stroke patients has not been elucidated.

The purpose of this study was to investigate the correlation between respiratory muscle strength improvement through respiratory training and cough capacity in stroke patients.

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SUBJECTS AND METHODS

The participants were 42 stroke patients (intervention group: n=21, control group: n=21) who received an explanation of the purpose of the study and provided written consent to participate in this study. The stroke patients had the symptoms for at least 6 months. The intervention group consisted of 9 males and 12 females, and the average age, height, weight, body mass index (BMI), and onset duration were 66.33 ± 3.89 years, 159.92 ± 6.97 cm, 58.02 ± 6.19 kg, 22.67 ± 1.85 kg/m^2, and 18.28 ± 5.39 months, respectively. The control group consisted of 9 males and 12 females, and the corresponding parameter values were 66.09 ± 3.16 years, 160.35 ± 7.04 cm, 55.30 ± 7.41 kg, 21.50 ± 2.46 kg/m^2, and 18.38 ± 4.80 months. This study was approved by the university institutional review board (CUPIRB-2014-023). The subjects of the present study were patients who had been diagnosed with stroke through computed tomography. The selection criteria for the subjects of this study followed the standard of previous research[12)]. The criteria for recruitment of subjects for the study were: (1) first episode of unilateral stroke with hemiparesis during the previous 12 months, (2) sufficient unilateral upper torso and extremity nerve function and strength to accomplish arm crank ergometry (ACE), (3) ability to understand and follow simple verbal instructions, (4) no previous history of cardiovascular or respiratory problems, (5) no medication that would influence metabolic or cardiorespiratory responses to exercise, and (6) no previous history of regular exercise training and sports activity to strengthen upper extremity and ventilatory muscles. The subjects were undergoing general physical therapy, including neurological treatment, though without special treatment to enhance pulmonary function. A spirometer (Pony Fx, Cosmed Srl, Italy) was used to measure pulmonary function (FVC), inspiratory muscle strength (MIP), and expiratory muscle strength (MEP), and a peak expiratory flow meter (Micro peak, Carefusion, UK) was used to measure cough capacity (PEF) before applying an intervention to each group[10)].

Respiratory muscle training was conducted using a Threshold Inspiratory Muscle Trainer (Respironics Inc., USA) and a Threshold Positive Expiratory Pressure device (Respironics Inc., USA). Three sets (3 repetitions per set) of expiratory muscle training and inspiratory muscle training were conducted 24 times over a span of 8 weeks. The training intensity was set to 40%, 60%, and 80% of the subject's MEP and MIP. The 3 intensity levels were gradually increased from low to high.

The collected data were analyzed using PASW Statistics for Windows (ver. 18.0). Pearson correlation analysis was performed in order to investigate the correlation of cough capacity with MIP, MEP, and FVC. Statistical significance was set at $p<0.05$.

RESULTS

The differences in variables before and after the 8-week intervention for each group are shown in Table 1. The correlation between cough capacity and respiratory muscle strength is presented in Table 2.

DISCUSSION

Although evidence suggests that inspiratory muscle training can improve the MIP in patients with neurological problems, there is a lack of evidence suggesting that inspiratory or expiratory muscle training can improve the MEP[2)]. In this study, combined inspiratory and expiratory muscle training improved both MIP and MEP in stroke patients.

Neuromuscular diseases (NMD) reduce the MIP and MEP while also decreasing the cough capacity by causing an imbalance between the inspiratory and expiratory muscles. The decrease in cough capacity causes pulmonary complications in patients with NMD, thereby increasing the morbidity and mortality[4)].

MIP/MEP ratio is a simple way to evaluate relative impairment of inspiratory and expiratory muscles. MEP in MEP/MIP was reported to be greater than MIP in both the healthy control group and patients with NMD[13)]. In this study, MEP in MEP/MIP was also greater than MIP in both the experimental and control groups. Although MEP/MIP did not show any change in the intervention group after 8 weeks of inspiratory and expiratory muscle training, MEP increased slightly more relative to MIP. In contrast, in the control group, MEP decreased to a greater extent than MIP did, after 8 weeks. This result coincides with findings obtained by a previous study, which reported that expiratory muscle strength decreases to a greater extent than inspiratory muscle strength in patients with NMD[4, 13)].

According to a study that investigated the correlation between cough capacity and respiratory muscle strength in patients with NMD, cough capacity is highly correlated with MIP and MEP[13)]. However, the degree of correlation between cough capacity and respiratory muscle strength varies as each disease exerts different influences on respiratory muscle weakness[4)].

In this study, cough capacity improved in the intervention group after respiratory muscle training. The increase in PEF was more closely related to increased MEP than to increased FVC or MIP. PEF decreased in the control group, where MEP, which had the highest correlation with cough capacity, also decreased.

In order to improve cough capacity in stroke patients, it is necessary to conduct both inspiratory and expiratory muscle training. In particular, increase in MEP is closely related to the improvement of cough capacity in stroke patients.

Table 1. The values of the variables measured before and after the intervention

	Group	Pre test (Mean ± SD)	Post test (Mean ± SD)	t	Δ
FVC (L)	Experimental	1.68 ± 0.20	1.79 ± 0.24	−6.57**	0.11 ± 0.08
	Control	1.72 ± 0.19	1.71 ± 0.22	−0.91	−0.01 ± 0.06
PEF (L/min)	Experimental	259.04 ± 18.94	279.52 ± 23.34	−9.16**	20.47 ± 10.23
	Control	264.76 ± 22.49	260.00 ± 23.02	3.62**	−4.76 ± 6.01
MIP (cmH_2O)	Experimental	20.33 ± 3.41	22.42 ± 3.32	−9.64**	2.09 ± 0.99
	Control	18.85 ± 2.45	18.76 ± 2.60	−0.623	−0.09 ± 0.70
MEP (cmH_2O)	Experimental	23.57 ± 4.53	26.00 ± 4.20	−8.91**	2.42 ± 1.24
	Control	21.71 ± 2.47	21.00 ± 2.58	5.83**	−0.71 ± 0.56
MEP/MIP	Experimental	1.16 ± 0.14	1.16 ± 0.15	−0.37	0.00 ± 0.06
	Control	1.15 ± 0.08	1.14 ± 0.09	−1.88	−0.01 ± 0.03

FVC: forced vital capacity, PEF: Peak expiratory flow, MIP: maximum inspiratory pressure, MEP: maximum expiratory pressure, Δ: difference between pre and post
**$p<0.01$

Table 2. Correlation between difference of PEF and FVC, MIP, MEP, MEP/MIP

	ΔFVC	ΔMIP	ΔMEP	ΔMEP/ΔMIP
ΔPEF	0.689**	0.677**	0.844**	0.617**

PEF: Peak expiratory flow, FVC: forced vital capacity, MIP: maximum inspiratory pressure, MEP: maximum expiratory pressure, Δ: difference between pre and post
**$p<0.01$

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