健康・スポーツ科学（2022）12(１)，27～31

【原著】

Effects of expiratory muscle training for elderly patients under long-term care

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Abstract

The purpose of this study was to investigate the effects of an expiratory muscle training (EMT) program on swallowing, tongue pressure and thickness, labial closure force, spirometry, and respiratory pressure in elderly patients under long-term care. The subjects were twenty elderly inpatients without dementia or dysphagia, who were under long-term care at the health facility of a hospital in Tokushima prefecture. They were randomly assigned to one of the two groups, the sham EMT group and the active EMT group. The improvement rates of SVC, %FVC, PEF, %PEF, MEP, %MEP and MIP were significantly different between two groups ($p < 0.01$). The EMT program was well-tolerated and led to improvements in respiratory function and muscle strength other than swallowing indices in elderly patients under long-term care. These results may contribute to the prevention and treatment of aspiration pneumonia in elderly individuals under long-term care.

Key words：expiratory muscle training, elderly patients, long-term care

Ⅰ Introduction

With age, respiratory muscle strength decreases and its stiffness increases[1]. In particular, diaphragmatic strength in the elderly is 13 to 25% less than in younger individuals[2]. Respiratory muscle training (RMT) as a treatment option for this weakness is widely used all over the world. RMT improves endurance exercise performance in healthy individuals, with greater improvements in less fit individuals and in sports with longer durations. All types of RMT (i.e., inspiratory muscle strength and expiratory muscle endurance training) can be used to improve exercise performance in healthy subjects[3]. RMT has played an important role in improving pulmonary function for many adult and pediatric patients with various disease with a variety of conditions, including stroke[4], Parkinson's disease[5], neurodegenerative diseases[6], chronic obstructive pulmonary disease[7] and heart failure[8].

The introduction of specific devices for inspiratory muscle training (IMT) seems to be a suitable method to improve performance in intermittent sports, mainly due to a reduction of the metaboreflex, fatigue sensation, and dyspnea[9]. A review study revealed for this paper revealed a positive trend for the effectiveness of IMT in improving inspiratory muscle performance in elderly subjects[10]. On the other hand, expiratory muscle training (EMT) generally improved their respiratory functions, particularly their vital capacity and peak expiratory flow, which significantly varied between before and after intervention. As EMT influences cough capacity, this may be a key to the prevention of aspiration pneumonia[11].

Pneumonia is a leading cause of death in the elderly, and such deaths are increasing in Japan. Elderly inpatients with pneumonia have a high incidence of aspiration pneumonia, which occurs in 70 to 80% of hospitalized patients with pneumonia over 70 years of age[12]. The main cause of aspiration pneumonia is an impairment in the swallowing and cough reflexes[13]. With regard to the cough reflex, strong coughing prevents aspiration pneumonia, and its strength is regulated by the respiratory muscles. Sarcopenia is a risk factor for pneumonia in older people, and

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Table 1. Subject group characteristics

	Active EMT group (N=10)	Sham EMT group (N=10)	P
Age (years)	87.5[83.0-89.5]	84.5[81.3-88.3]	NS
Gender (M/F)	3/7	4/6	NS
Disease	OA 4, fracture 3 brain disease 2, other 1	OA 3, fracture 3 cardiac disease 3, other 1	
BMI	24.4±2.3	21.3±3.7	P<0.05
Barthel Index	92.5[90.0-95.0]	90.0[82.5-95.0]	NS

mean±SD, median〔25%tile-75%tile〕

OA:Osteoarthritis

aspiration pneumonia inpatients with low muscle mass show high mortality rates[14]. Diaphragmatic atrophy may weaken the force of coughing to expectorate sputum or mis-swallowed contents. Thus, muscle atrophy could become a new therapeutic target for aspiration pneumonia[15].

A meta-analysis provided evidence that respiratory muscle training is effective in reducing the risk of respiratory complications, and in improving dysphagia by reducing penetration or aspiration during swallowing liquid bolus after stroke[16]. Recently, it has been suggested that a decrease in the mass or strength of the swallowing muscles was associated with reduced swallowing function[14]. Tongue-pressure resistance training improved tongue strength, dexterity, both anterior and superior hyoid elevation, and swallowing functions[17]. Thus, tongue function is related to swallowing.

It is unclear whether EMT is an effective program to enhance swallowing function, tongue function, respiratory function, and muscle strength in the elderly under long-term care. The purpose of this study was to investigate the effects of an EMT program on swallowing, tongue pressure and thickness, labial closure force, spirometry, and respiratory pressure in elderly patients under long-term care.

II Methods

The subjects were twenty elderly inpatients without dementia or dysphagia, who were under long-term care at the health facility of a hospital in Tokushima prefecture from July 2018 to March 2020. They were randomly assigned to one of the two groups. Their characteristics are shown in Table 1. This study was conducted as a prospective, single-center, single-blind, randomized, sham-controlled trial. They completed four weeks at five sets of five breaths through the device for a total of 25 breaths, twice a day, two days per week, of either active EMT (n=10, seventy-five percentage loading of maximal expiratory pressure) or sham EMT (n=10, zero percentage loading training) under medical staff supervision. Routine oral care was provided to all subjects. Threshold IMT® respiratory muscle training equipment with a special attachment was used in reverse[18] for both groups.

The primary outcomes to assess treatment efficacy were changes in the repetitive saliva swallowing test (RSST) and modified water swallow test (MSWT). Secondary outcomes included pulmonary functions, respiratory muscle strength and Barthel Index. These were slow vital capacity (SVC), percentage of predicted SVC (%SVC), forced vital capacity (FVC), percentage of predicted FVC (%FVC), peak expiratory flow (PEF), percentage of predicted PEF

(%PEF), maximal expiratory and inspiratory pressure (MEP/MIP) and scores for activities of daily living. The Barthel Index consists of 10 items that measure a person's daily functioning, particularly the activities of daily living and mobility. The items include feeding, transfers from bed to wheelchair and to and from a toilet, grooming, walking on a level surface, going up and down stairs, dressing, continence of bowels and bladder. These ten activities are scored, and the values are added to give a total score from 0 (totally dependent) to 100 (completely independent).

In addition, tongue thickness related to nutritional status in the elderly was measured by ultrasonography (Vscan, GE Healthcare Japan Co., Ltd., Tokyo, Japan)[19]. Tongue pressure and labial closure force (LCF) were measured using a tongue pressure measurement system (JMS Co., Ltd., Hiroshima, Japan) and the Lip De Cum (Cosmo Instruments Co., Ltd., Tokyo, Japan). Differences between pre- and post-training values in each group were evaluated using Student's t-test and the Wilcoxon signed-rank test for paired values. The improvement rates between two groups were evaluated using unpaired t-test and the Mann-Whitney U test for unpaired values. The significance level was set at $p<0.01$ in SPSS ver. 26. This study has been approved by the research ethics committee of Mukogawa Women's University (No. 16-68).

III Results

EMT was well tolerated with 100% of patients completing the protocol. No adverse events occurred. The descriptive statistics were expressed as average± standard deviation or median and interquartile range in each index of two groups (Table 2).

The improvement rates of SVC, %FVC, PEF, %PEF, MEP, %MEP and MIP were significantly different between two groups ($p<0.01$, Table 3).

IV Discussion

This study indicated that EMT with good training adherence for the elderly under long-term care may improve respiratory function and respiratory muscle strength. Nevertheless, representative indicators such as RSST and MSWT did not show an effect on their swallowing function. The results of four weeks of EMT protocols consisting of seventy-five percentage loading

Table 2. Mean and median values of respiratory indices for each group in pre- and post-training

	Active EMT group (N=10)		Sham EMT group (N=10)	
	pre-training	post-training	pre-training	post-training
RSST(times)	4[3-5]	4.5[3-5]	4.5±1.4	4.3±1.4
MSWT(score)	5[5-5]	5[5-5]	5[5-5]	5[5-5]
Tongue pressure(kPa)	25.5±3.3	30.6±5.4	31.9±11.6	32.4±13.4
Tongue thickness(cm)	4.1±0.3	5.4±1.7	4.0±0.4	4.1±0.5
LCF(N)	9.7±1.7	10.9±2.0	12.6±3.0	12.6±3.9
SVC(l)	1.801±0.346	1.936±0.334	1.873±0.335	1.875±0.361
%SVC(%)	81.8±21.5	89.8±24.6	79.2±15.7	76.7±18.4
FVC(l)	1.752±0.236	1.887±0.418	1.814±0.294	1.895±0.356
%FVC(%)	87.4±22.7	97.1±21.3	81.6±14.9	80.4±21.3
PEF(l/min)	256.6±56.9	294.2±72.9	280.4±94.2	282.3±90.7
%PEF(%)	69.3±17.5	78.5±17.6	70.5±19.1	68.5±18.8
MEP(cmH2O)	47.7±8.7	59.0±12.2	50.6±16.6	51.4±17.8
%MEP(%)	71.6±19.1	87.1±18.1	70.0[59.5-89.3]	64.5[49.8-99.0]
MIP(cmH2O)	35.5±15.7	41.8±16.4	34.7±9.7	34.2±12.7
%MIP(%)	81.9±45.8	94.4±48.0	75.3±28.7	72.3±35.1

mean±SD, median〔25%tile-75%tile〕

RSST: repetitive saliva swallowing test, MSWT: modified water swallow test, LCF: labial closing force
SVC: slow vital capacity, FVC: forced vital capacity, PEF: peak expiratory flow
MEP: maximal expiratory pressure, MIP: maximal inspiratory pressure

Table 3. Group mean and median values of the rate of improvement in each respiratory index

	Active EMT group（N=10）	Sham EMT group（N=10）	P
RSST(%)	0[0-0]	0[0-0]	NS
MSWT(%)	0[0-0]	0[0-0]	NS
Tongue pressure(%)	-4.0[-18.3-36.4]	-0.9[-3.0-0.3]	NS
Tongue thickness(%)	-1.3[-2.4-4.5]	0[0-0.2]	NS
LCF(%)	-10.1±23.7	-1.9±8.0	NS
SVC(%)	10.4±12.6	-5.4±6.8	0.008
%SVC(%)	6.8±11.3	-0.9±9.4	NS
FVC(%)	14.1±22.7	-0.8±9.4	NS
%FVC(%)	14.4[6.5-18.1]	-1.3[-5.2-0.7]	0.001
PEF(%)	14.3±10.4	-2.6±6.3	0.001
%PEF(%)	24.0±13.3	-2.8±8.9	0.001
MEP(%)	24.0±13.2	-2.7±8.9	0.001
%MEP(%)	23.3[13.2-26.5]	-8.8[-12.4-0.7]	0.001
MIP(%)	17.4±11.3	-8.9±14.7	0.001
%MIP(%)	0[0-0]	0[0-0]	NS

mean±SD, median〔25%tile-75%tile〕

of MEP, five times per day, five days a week, and fifteen to twenty minutes per day, the same as the loading pressure and frequency per week in this study, indicated up to a 50% improvement of respiratory muscle strength for sedentary eldely, those with multiple sclerosis, and those with spinal cord injury[20]. In the active EMT group of this study, the improvement rate was 10 to 15% for spirometry and 24% for expiratory muscle strength. This may be due to the relatively high baseline of respiratory function in the group. A systematic review suggested that EMT improved airway safety during swallowing in people with dysphagia and increased the strength of expiratory muscles in all patient groups[21]. The results in this study may contribute to the prevention and treatment of aspiration pneumonia in the elderly, especially as improved expiratory flow and strength contributes to the excretion of airway secretions.

MIP, one of the important indicators of respiratory muscle strength, has been used to operationally define respiratory sarcopenia[22]. However, it is clear that loss of muscle mass plus low muscle strength causes weakness in the respiratory muscles. It is impossible to deny the possibility that the decrease in mass and strength of limb skeletal muscles that occurs in sarcopenia is preceded by a decrease in mass and strength of respiratory muscles[23]. The mean Barthel index of all subjects in this study was beyond a score of 90 and most of them are thought to have been functionally independent. However, the relationship between limb and respiratory muscle function is unknown, as we have not measured data related to sarcopenia.

This research has some limitations. The sample size was very small for a single-center study. Furthermore, many elderly people with dementia were excluded from this study. In addition, we were waiting for the COVID-19 situation to be resolved, but clinical research in the hospital became difficult. As a result, the period of this study was shortened. Further studies with any option in addition to EMT for elderly with more sample size are required in the near future.

V Conclusion

The EMT program was well-tolerated and led to improvements in respiratory function and respiratory muscle strength other than swallowing indices in elderly patients under long-term care. These results may contribute to the prevention and treatment of aspiration pneumonia in the elderly.

The authors have no financial conflicts of interest to disclose concerning the presentation.

Acknowledgement

This work was supported by JSPS KAKENHI Grant Number JP16K01485.

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