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Original Article

The Effects on the Pulmonary Function of Normal Adults Proprioceptive Neuromuscular Facilitation Respiration Pattern Exercise

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Abstract. [Purpose] The purpose of this study was to determine whether proprioceptive neuromuscular facilitation (PNF) respiration exercise increases the pulmonary function of normal adults. [Subjects and Methods] Twenty-eight normal adults in their 20s were randomly assigned to an experimental group (n=14) or control group (n=14). Over the course of four weeks, the experimental group participated in PNF respiration pattern exercises for 30 minutes three times per week. Subjects were assessed pre-test and post-test by measurement of pulmonary function (tidal volume, inspiratory reserve volume, expiratory reserve volume, inspiratory capacity, and vital capacity). [Results] Our findings show that the experimental group had significant improvements in expiratory reserve volume and vital capacity. In the comparison of the two groups, the experimental group had higher pulmonary function than the control group. [Conclusion] In this study, the experimental group showed greater improvement in pulmonary function than the control group, which indicates that the PNF respiration exercise is effective at increasing the pulmonary function of normal adults.

Key words: Pulmonary function, Proprioceptive neuromuscular facilitation, Respiration

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INTRODUCTION

Given that the goal of breathing exercise interventions is to minimize disabilities resulting from diseases and to prevent recurrence, rather than complete recovery from disease, developing and applying diverse programs that can prevent decreases in respiratory activities and promote the functional performance of breathing is very important[1)]. Respiratory muscle strength and endurance can be improved by various breathing exercises which can consequently improve respiratory functions[2)].

Thus far, breathing exercises using direct interventions that improve respiratory functions have been performed by diverse subjects. Many studies have been conducted, including studies of vital capacity using high frequency inspiratory muscle training for normal persons[3)], respiratory muscle training for normal persons[4)], pursed-lip breathing exercises performed by COPD patients[5, 6)], exercises combining diaphragmatic breathing exercises and pursed-lip breathing exercises[7)], diaphragmatic breathing exercises performed by PMD patients[8)], respiratory muscle strengthening exercises performed by inspiratory muscle weakness patients[9)], breathing exercises using pursed-lip breathing exercises and diaphragmatic breathing exercises performed by stroke patients[10)], forced breathing exercises[11)], and chest expanding exercises[12)].

Although many studies have conducted respiratory muscle training based on the theory that pulmonary functions are improved through direct respiratory function strength training, it is true that these studies comprise simple self-breathing exercises or one-dimensional basic resistive breathing exercises. A study conducted by Dietz[13)] indicated that muscle strength can be improved through three-dimensional spiral large scale resistive exercises using proprioceptive neuromuscular facilitation (PNF). Therefore this study examined the improvement of respiratory functions induced by direct respiratory muscle resistive exercises through the PNF respiration pattern. Although this study was limited in that the experimental subjects were normal persons, clinical grounds for actual implementation of the exercises will be prepared based on its results.

SUBJECTS AND METHODS

Subjects

The study subjects were 28 university students attending N University in Cheonan, Chungnam. The study subjects were randomly assigned to an experimental group of 14 subjects and a control group of 14 subjects. The subjects were selected from among those who had no particular history of lung diseases, had no accompanying damage, such as congenital deformation of the chest, and had not received any particular treatment to improve pulmonary functions.

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The subjects understood the purpose of this study and consented to participation in it. This study was approved by the International Review Board of the Korea Nazarene University and was conducted in accordance with the ethical principles of the Declaration of Helsinki. The general characteristics of both groups are shown in Table 1.

Table 1. General characteristics of the subjects

	EG (n=14)	CG (n=14)
Sex (M/F)	7/7	9/5
Age (years)	21.1 ± 0.3	22.8 ± 0.3
Height (cm)	169.7 ± 4.0	172.2 ± 4.9
Weight (kg)	54.5 ± 4.5	54.7 ± 4.7

Values are means ± SD, EG: experimental group; CG: control group

Methods

The training of the experimental group was conducted three times per week for four weeks, and it consisted of 30 minutes of PNF breathing exercises a session. When performing the PNF breathing exercises were performed, the subjects were in a supine position. A therapist placed his open hands on the lateral surfaces on both sides of the 8, 9, 10, and 11th ribs of the subject. The therapist instructed the subjects by saying, “Take a deep breath”. As the subjects’ ribs moved upward and laterally, the therapist assisted the movement of the subjects’ ribs to promote the subjects’ respiration pattern. At the subjects’ maximum inspiration, the therapist said, “Hold your breath for five seconds” while dorsomedially applying soft manual resistance to the lower rib regions on both sides. When the subjects’ breathed out, the therapist said, “breathe out Maximally”. At this time, the subjects’ ribs moved downward and medially. At maximum expiration, the therapist pushed the lower rib regions on both sides upward while gathering the regions dorsomedially, and the therapist shook the region to assist with the discharge of the air remaining in the lungs[14, 15].

The control group performed 30 minutes of diaphragmatic breathing exercises a session three times per week for four weeks. The subjects prepared by adopting a supine position. For the breathing exercises, a therapist placed his hands on the top of the rectus abdominis, immediately below the anterior costal cartilage, and then requested the subjects to breathe in slowly and deeply with the nose, to relax, and to not move the upper chest while allowing only the ascent of the abdomen. Next, the therapist instructed the subjects to exhale all the air slowly[16].

If any subject reported fatigue or dizziness during the breathing exercise, he or she was given a rest was given and the exercise was performed again. The therapist reviewed the exercise methods with the subject two to three times before the experiment so that the subject knew what to expect.

Measurements were conducted in the sitting position using Fit Mates (COSMED Srl, Italy), which are measuring instruments for pulmonary function tests. To ensure accuracy, explanations and demonstrations of the procedures were given prior to the measurements. The experimental group and the control group were instructed to use a mouthpiece, and the subjects’ noses were closed during the measurement so that air could not be inhaled or exhaled through the nose. Beginning from expiration, the subject was instructed to slowly breathe out completely, and then breathe in slowly when the tester gave a signal. The values of the tidal volume (TV), inspiratory reserve volume (IRV), expiratory reserve volume (ERV), inspiratory capacity (IC), and volume capacity (VC) were measured. The measurements were conducted three times both before and after the experiment, and the average values of the three measured values were used in the analysis. A resting time of five minutes was given after each measurement[17].

In this study, SPSS ver. 12.0 was used to examine the general characteristics of the subjects and to obtain the means and standard deviations of individual groups. The paired sample t-test was used to compare pulmonary functions before and after the intervention, and the exercise and independent sample t-test was used to examine the differences between the measurements taken before and after the experiment between the groups. The statistical significance level was chosen as 0.05.

RESULTS

Here we review the comparison of vital capacities before and after the intervention between the experimental group and the control group. The experimental group showed significant differences in TV, ERV, and VC ($p<0.05$), but did not show any significant difference in IRV and IC ($p>0.05$). The control group did not show any significant difference in any of the measured items ($p>0.05$). In the investigation of differences between before and after the experiment between the intervention group and the control group, significant differences were found for in ERV and VC ($p<0.05$) but not for TV, IRV, and IC ($p>0.05$) (Table 2).

DISCUSSION

Although breathing exercises should be actively used as interventions, in recent clinical practice in Korea many problems with respiration appear as chronic disease patients age, and interventions rely on simple self-breathing exercises, ventilator tube exercises, or drug treatments. However, as Korea becomes more westernized, the number of subjects who require breathing exercises will increase. Since the usefulness of direct manual resistive exercises has been extensively proven[18, 19], diverse breathing exercise intervention methods that will implement direct interventions should be developed. The present study examined the effects of a PNF pattern exercise that can induce large scale spiral movements of the lower chest walls on the pulmonary functions of normal persons in their 20s. The number of repetitions, the duration, and the length of rest time should be considered to minimize subjects’ muscle fatigue and efficiently increase muscle strength[11]. Given that interventions are effective only when implemented for at least 20–30 minutes, two to five times per week for 4–12 weeks[20], in this study, the interventions were conducted for 30 minutes, five times per week for four weeks.

Table 2. The comparison of respiration function between experimental group and control group

	EG		CG	
	Pre-test	Post-test	Pre-test	Post-test
TV (L)	0.7 ± 0.2	0.9 ± 0.0*	0.7 ± 0.0	0.8 ± 0.0
IRV (L)	2.2 ± 0.1	2.4 ± 0.1	2.4 ± 0.1	2.5 ± 0.1
ERV (L)	1.5 ± 0.0	1.8 ± 0.0*[a]	1.6 ± 0.0	1.6 ± 0.0[a]
IC (L)	3.1 ±0.36	3.4 ± 0.2	3.2 ± 0.1	3.3 ± 0.2
VC (L)	4.7 ± 0.2	5.3 ± 0.2*[a]	4.8 ± 0.6	5.1 ± 0.1[a]

Mean±SE, TV: Tidal volume, IRV: Inspiratory reserve volume, ERV: Expiratory reserve volume, VC: Volume capacity, *Significant difference from before the intervention, $p < 0.05$. [a] Significant difference in changes between the two groups, $p < 0.05$.

Vital capacity measurements are indicators that reflect the reserve capacity of ventilation. The subjects were instructed to breathe normally before breathing in completely, and then slowly breathe out as completely as possible, regardless of time, to measure TV, IRV, IRV, IC, and VC[21]. The results are regarded as being normal when they fall within ±20% of the estimated normal value for the sex, age, height, and weight of the patient[22].

Pulmonary function tests were conducted after four weeks of intervention. The experimental group showed significant increases in TV, ERV, and VC after the intervention compared to measurements taken prior the intervention, but they did not show significant increases in IRV or IC. The control group showed no significant increases in any of the measured items. In the examination of pretest-posttest changes in the experimental group and the control group, although the experimental group showed larger increases than the control group in all measurements, the differences were significant only for ERV and VC. The large increases in vital capacity are attributable to the fact that when the subject was breathing in, the therapist promoted the activities of the diaphragm and other assistant inspiratory muscles. This was done first with an increase of intra-abdominal pressure through the resistive inspiration movement caused by pushing both sides of the subject's chest walls toward the head to cause spiral movements. When the subject was breathing out, the mobility of the chest walls was increased as much as possible to induce maximum lung ventilation by giving assistive movements with medial gathering of the lower chest walls.

Enright et al.[3] reported that vital capacity, total vital capacity, inspiratory muscle strength, and inspiratory muscle endurance were significantly increased by high frequency inspiratory training performed by normal persons, and Townsend[4] found that when breathing exercises were performed by normal persons, the results of inspiratory volume and those of expiratory volumes showed large differences. Estenne et al.[23] reported an increase of 47% in expiratory reserve volume in quadriplegia patients they performed pectoralis major muscle strengthening exercises. Liaw et al.[24] reported that after resistive inspiratory muscle strengthening exercises were performed by spinal cord injury patients; the experimental group showed a 67% change in vital capacity, while the control group showed a 27% change. Jones et al.[7] reported that respiration volume per breath cycle at normal times were increased by diaphragmatic breathing exercises performed by COPD patients, and that increases in final inspiration volumes and momentary amounts of ventilation appeared in COPD patients after pursed-lip breathing exercises. Increases in respiration volumes of patients with chronic obstructive pulmonary disease occurred after pursed-lip breathing exercises[6]. Scherer et al.[25] reported that after continuous breathing exercises, COPD patients saw significant increases in ventilatory and inspiratory threshold load and expiratory pressure, and Satori et al.[26] observed that feedback breathing exercises significantly increased fibrous cyst patients' forced expiratory volume in 1 second. In previous studies, pulmonary functions were improved by diverse exercises aimed at improving the respiratory activities of normal persons, lung disease patients, and nervous system disease patients. PNF breathing exercises showed similar effects to those of direct breathing exercises, for normal persons.

The experimental group showed greater improvements in the pulmonary functions of TV, IRV, ERV, IC, and VC than the control group. In the experimental repetitive PNF breathing exercises, the mobility of the subjects' chest walls increased, which led to improvements in pulmonary function. Breathing physical therapy has not yet been universalized in rehabilitation centers in Korea. Given that breathing physical therapy has already been universalized in advanced countries, when breathing physical therapy interventions become more popular in Korea through the development of diverse physical therapies, many opportunities to implement effective breathing intervention programs for patients with weak cardiopulmonary functions will appear.

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