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Comparison of The Effects of Respiratory Exercise between Smokers and Non-smokers on Pulmonary Function and Muscle Activity of Rectus Abdominis with The Elderly People

The purpose of this study was to compare the effects of respiratory exercise on cardiopulmonary function and muscle activity of rectus abdominis in smokers and non-smokers with elderly people. All the participants were older than 65 years, and twenty non-smokers, and twenty smokers participated. Non-smokers and smokers were randomly divined into 10 feedback breathing exercises (FBE) and a balloon-blowing exercise (BBE) group. The FBE and the BBE were performed three times a week for four weeks. Forced vital capacity (FVC), forced expiratory volume at one second (FEV1), forced expiratory volume at one second/forced vital capacity (FEV1/FVC), peak expiratory flow (PEF), and vital capacity (VC) were measured as pulmonary function. EMG was used to measure the activity of the rectus abdominis. In the FBE and BBE groups, FEV_1 was significantly lower in non-smokers compared to smokers at two and four weeks ($p<.05$), FEV_1/FVC, PEF and VC were significantly lower in non-smokers compared to smokers to pre-test, two weeks, four weeks and six weeks ($p<.05$). Muscle activity of rectus abdominis was significantly difference in the BBE group at pre-test, two weeks, four weeks, and six weeks ($p<.05$). These results suggest that respiratory exercise was effective in improving pulmonary function and rectus muscle activity.

Key words: *Feedback breathing exercise, Balloon-blowing exercise, Respiratory exercise, Pulmonary function, Elderly*

Hyun Ju Jun[a], Ki Jong Kim[b]

[a]Vision College of Jeonju, Jeonju; [b]Cheongam College, Suncheon, Korea

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Address for correspondence
Ki Jong Kim, PT, Ph.D
Department of Physical Therapy,
bCheongam College, 1641, Noksaek-ro,
Suncheon-si, Jeollanam-do, Korea
Tel: 82-61-740-7339
E-mail: kjparadise@hanmail.net

INTRODUCTION

The elderly population aged 65 and over is showing an increasing trend in South Korea due to economic growth and development of medical technology [1]. The elderly may have significant differences in their aging patterns due to diseases, physical factors, and common living habits, and pulmonary function and body strength are important factors to maintain independent daily activities among the elderly [2].

In addition to aging, environmental pollution also negatively affects cardiopulmonary function severely for the elderly. Recently, citizens living in South Korea are exposed to air pollution due to domestic causes such as car smoke and foreign causes coming from China and other countries. In addition, the elderly is forced to stay in the house for more time due to their physical limitations and health reasons, but indoor air is also polluted and directly affects the cardiopulmonary function to the elderly [3].

The weakening of the respiratory muscles and the increase in stiffness of the chest wall due to the elderly decrease the peak cough flow and cause the complication of the respiratory system because the airway secretion cannot be removed [4]. In addition, hyperpnea occurs due to insufficient oxygen supply, and fatigue also increases during the contraction of diaphragm, abdominal muscles, and around chest muscles [5]. In addition to the weakening of the respiratory system of elderly people, the addition of geriatric diseases may lead to a decrease in daily activities and an increase in morbidity and mortality due to the weakening of physical functions [6].

The weakening of cardiopulmonary functions by the elderly is also a problem, but the worse is when the function is weakened by smoking. The number of deaths due to smoking has increased 2.3 times for men and 2.7 times for women based on the 2012 statistics of Koreans [7]. Smoking is a major cause of various diseases such as chronic bronchitis, asthma, and lung cancer, and sometimes causes life-threatening consequences [8,9]. Interestingly, they are interested smoking irregularly in adolescence but when it is over 21.2 years old, it tends to smoke more than one time per day regularly [10]. Considering the increasing trend of the elderly population due to aging, the onset of smoking from adolescence or early 20s means long-term smoking and the problems caused by the smoking of the elderly are expected more seriously.

It is effective to perform breathing exercises to strengthen weakness of cardiopulmonary function. The purpose of the respiratory exercise is to increase the ability of daily living activities and improve the quality of life by control exhalation, increasing muscle strength, coordination of respiratory muscle, decreasing dyspnea and improving lung function [11,12]. However, studies on cardiorespiratory physiotherapy are very few, and we think that more efforts are needed now and in the future to recognize the importance for the function for the public. Therefore, the purpose of this study is to compare the effects of respiratory exercise on pulmonary function in smokers and non-smokers.

METHODS

Subjects

The Preliminary review and research approval of this study were carried out by the Bioethics Committee of Dongshin University (IRB No. 201406-BM-001-02). All subjects were explained the purpose to the study and then gave them inform consent for signed it. The subjects were 20 non-smokers and 20 smokers aged 65 and over who had at least one year of smoking in their past or present life. All subjects were recruited through the M Welfare Center in Mokpo city, South Korea. The non-smoking participants and the smoking participants were randomly assigned to the Feedback Breathing Exercise (FBE) group and the Balloon-Blowing Exercise (BBE) group. For the randomization method, two tickets were prepared, and when the participant selected 1, they were assigned to the FBE group or when 2 were selected, they were assigned to BBE group. The duration of respiratory intervention was four weeks, followed by a follow-up test for two weeks, which took a total of six weeks. Table 1 shows that the general characteristics of the subjects.

Study Design and Intervention

FBE and BBE were conducted three times a week to a total of four weeks. The pulmonary function of subjects and muscle activity were measured by pre-test, mid-test (two weeks), post-test (four weeks) and follow-up test at six weeks. FBE was applied by SPIRO TIGER® (Idiagch, Switzerland), which can provide the sign when is starting time to inhale and exhale, and give visual and auditory feedback. This exercise was performed for 15 minutes. BBE performed three sets per day, and one set was implemented more than 1 minute. All exercise programs were conducted with the sufficient rest, considering conditions such as elderly's heart pain and dizziness.

Measures

The pulmonary function of the breathing exercise was measured using a Cardio Touch 3000S (Bionet, Korea) in a sitting position. The pulmonary function was measured for forced vital capacity (FVC), forced expiratory volume at one second (FEV_1), FEV_1/FVC, peak expiratory flow (PEF), and vital capacity (VC). All measurements were conducted at three times for reliable results and selected as the highest value among them13).
Pocket EMG (BTS co, Italy) was used to measure the activity of the rectus abdominis muscle. The left and right rectus abdominis muscles were measured using 4 channels out of 16 channels using the sampling frequency of 1KHz. The electrode was attached 2 cm laterally, 1 cm above the navel. The EMG signals measured across the electrodes were amplified 10 times to prevent noise and interference, and they were moved along the cable and converted directly to digital data using a 16-bit A/D converter. Data collected from the research subjects were received by an access pointer connected to the computer and LAN cable through the wireless LAN communication system

(WIFI) at the same time as the collection was completed. Then, raw data from Pocket EMG that automatically displayed in Myolab (BTS co, Italy) was used for this study.

Statistical analysis

In this study, the general characteristics and all other measurement data were analyzed using the SPSS 21.0 version. Independent t-tests were performed to compare each week of the pulmonary function of the smokers and non-smokers of FBE and BBE and the muscle activity of the rectus abdominis. Alpha for the significance test of all data was set at 0.05.

RESULTS

FBE group

The FVL was significantly lower in smokers compared to non-smokers in the pre - test, and were not significantly different at two and four weeks ($p>.05$), and again significantly at six weeks ($p<.05$). FEV_1, FEV_1/FVC, PEF and VC measurements were significantly lower in smokers compared to non-smokers in pre-test, two weeks, four weeks and six weeks ($p<.05$)(Table 2). The muscle activity of rectus abdominis was not significantly different between smokers and non-smokers at pre-test, two, four, and six weeks ($p>.05$)(Fig. 1).

BBE group

The FVL was significantly lower in smokers compared with non-smokers at pre-test ($p<.05$), but there was no significant difference at two, four, and six weeks ($p>.05$). There was no significant difference in FEV_1 at pre-test, two weeks, and four weeks ($p>.05$), but smokers were significantly lower at six weeks compared to non-smokers ($p<.05$). FEV_1/FVC, PEF, and VC were significantly

Table 1. General characteristics of the subjects

	Smoking group(n=20)		Non-smoking group(n=20)	
	FBE	BBE	FBE	BBE
Sex(male/female)	8/2	7/3	3/7	4/6
Age(years)	72.60±9.00a	70.00±3.50	73.00±4.60	77.00±6.10
Height(cm)	163.20±6.39	152.69±6.33	153.66±6.31	167.02±7.85
Weight(kg)	66.64±9.87	59.45±9.58	60.54±9.24	62.85±9.14

[a]Values are showed mean ± SD,
FBE: Feedback breathing exercise, BBE: Balloon-blowing exercise

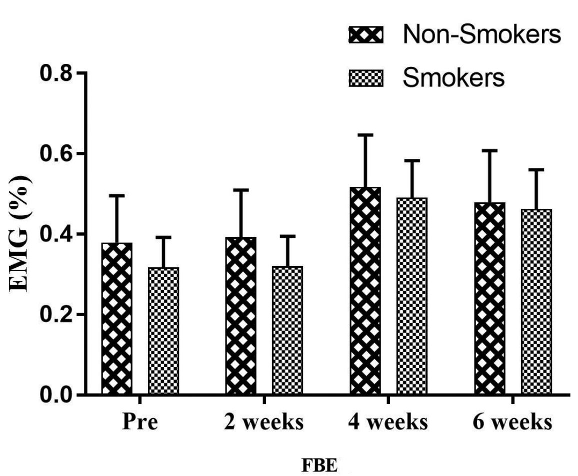

Fig. 1. Changes of rectus abdominis of muscle activities between smokers group and non-smokers group after feedback breathing exercise. FBE: Feedback breathing exercise

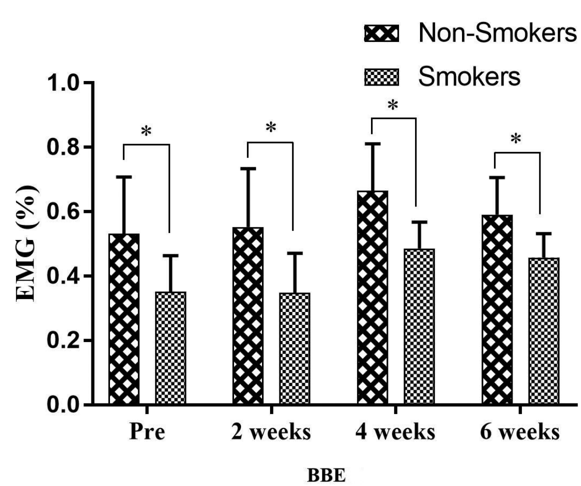

Fig. 2. Changes of rectus abdominis of muscle activities between smokers group and non-smokers group after balloon-blowing exercise BBE: Balloon-blowing exercise

Table 2. Changes of pulmonary function between non-smokers group and smokers group

Pulmonary function		FBE			BBE		
		Non-smoker	Smoker	p	Non-smoker	Smoker	p
FVC(L)	pre	3.59±0.19a	3.40±0.19	0.030*	3.54±0.33	3.26±0.28	0.038*
	2 weeks	3.60±0.18	3.44±0.24	0.117	3.56±0.22	3.46±0.61	0.630
	4 weeks	3.98±0.28	3.77±0.30	0.119	4.01±0.35	3.89±0.50	0.519
	6 weeks	3.92±0.21	3.66±0.20	0.008*	3.89±0.27	3.64±0.41	0.135
FEV1(L)	pre	3.11±0.22	2.68±0.54	0.039*	2.95±0.28	2.64±0.43	0.073
	2 weeks	3.15±0.22	2.70±0.55	0.034*	3.01±0.29	2.69±0.46	0.077
	4 weeks	3.69±0.24	2.80±0.61	0.001*	3.45±0.34	3.23±0.40	0.188
	6 weeks	3.50±0.30	2.71±0.52	0.001*	3.41±0.35	2.78±0.47	0.003*
FEV1/FVC (%)	pre	88.70±3.27	69.90±9.50	0.000*	88.20±3.12	73.00±9.07	0.000*
	2 weeks	89.70±3.27	69.90±9.80	0.000*	88.90±3.18	73.10±9.50	0.000*
	4 weeks	93.20±3.77	74.10±9.35	0.000*	92.10±4.09	76.10±9.61	0.000*
	6 weeks	92.70±3.09	69.90±8.97	0.000*	91.50±3.60	73.30±10.50	0.000*
PEF(L)	pre	5.64±1.47	4.20±1.39	0.037*	4.97±1.10	3.40±1.16	0.006*
	2 weeks	5.67±1.47	4.20±1.39	0.034*	5.00±1.10	3.40±1.19	0.006*
	4 weeks	6.00±1.47	4.24±1.39	0.013*	5.27±1.20	3.64±1.24	0.008*
	6 weeks	5.91±1.51	4.20±1.38	0.017*	5.23±1.20	3.53±1.24	0.006*
VC(L)	pre	3.42±0.43	2.95±0.43	0.028*	3.56±0.29	2.98±0.37	0.001*
	2 weeks	3.46±0.46	2.95±0.43	0.021*	3.60±0.30	2.99±0.37	0.001*
	4 weeks	3.82±0.47	3.32±0.49	0.031*	3.92±0.43	3.31±0.30	0.001*
	6 weeks	3.72±0.51	3.22±0.51	0.043*	3.84±0.32	3.23±0.04	0.002*

[a]Values are showed mean ± SD, Tested by independent t-test (*: p<.05)
FVC: Forced vital capacity, FEV_1: Forced Expiratory Volume at one second
PEF: Peak expiratory flow, VC: Vital capacity
FBE: Feedback breathing exercise, BBE: Balloon-blowing exercise

lower in pre-test, two weeks, four weeks, and six weeks smokers compared with non-smokers (p<.05)(Table 2). Muscle activity of rectus abdominis was significantly lower in pre-test, two weeks, four weeks, and six weeks compared to non-smokers (p<.05)(Fig. 2).

DISCUSSION

In this study, we performed four weeks FBE and BBE for non-smokers and smokers of elderly. Measurements were forced vital capacity (FVC), forced expiratory volume at one second (FEV_1), FEV_1/FVC, peak expiratory flow (PEF), vital capacity (VC) and the activities of rectus abdominis. Intervention was carried out three times a week, and measurements were performed after two weeks, four weeks and six weeks to compare the effects of non-smokers and smokers.

In current study, there was no significant difference in FVL between smokers and non-smokers at two weeks and four weeks. It is interpreted that FVL, which had a difference in advance, reduced the difference between smokers and non-smokers through FBE breathing training. However, after six weeks there was a significant difference between the two groups, indicating that the effects of FBE duration to the smokers were not long. In previous studies, FVL increased 7% in the calcium-fed group without the exercise, but increased 10% in the calcium-fed with the aerobic exercise group [14]. The findings of this study suggest that respiration training may be more effective for non-smokers, although it may help FVL for smokers.

FEV_1, FEV_1/FVC, PEF, and VC measurements in the FBE group were significantly lower than those of non-smokers in smokers consistently from pre-test to six weeks. According to Kim13) study shown, that FVC, FEV_1, and FEV_1/FVC were decreased with increasing age. In addition, inspiratory muscle training for twelve weeks significantly increased FVC, FEV_1, FEV_1/FVC, and PEF in elderly atrial fibrillation patients [15]. Therefore, we think that FBE exercise is effective for pulmonary function in both smokers and non-smokers, but we also think that this exercise is not as much of a pulmonary function which is reduced because of smoking before. Furthermore, authors think it is necessary to expand the role of professional respiration physiotherapists in hospitals that inform the awareness of smoking to patients, and to expand public service advertisements that can increase societal awareness.

The elderly people are accompanied by a decrease in the movement of the diaphragm due to ventilator failure and the removal of airway secretion due to weakening of the surrounding respiratory muscles as well as the problem of the lung itself [16]. These results are from the narrowing of the respiratory muscles, such as rectus abdominis and ribs, as they get older [17]. In the present study, no significant differences were found between smokers and non-smokers in the rectus abdominis from the beginning of the FBE group to the six weeks. In other words, muscle activity of rectus abdominis between smokers and nonsmokers is not different, and this result is unlike from the pulmonary function of this study. The authors think that rectus abdominis is the muscle involved in respiration, but this is the opposite result because it is an auxiliary muscle rather than an agonist muscle. In previous studies, the respiratory physiotherapeutic program did not reveal any significant EMG changes in diaphragm and rectus abdominis [18], and that results supported our study.

In the BBE group, there was a significant difference between smokers and nonsmokers in FEV_1/FVC, PEF, and VC from baseline to six weeks. This is similar in the FBE group in this study. Based on this point, we think it is important for physiotherapists to consider whether they are smoking when they perform cardiopulmonary physical therapy. Authors recommend that cardiorespiratory physiotherapy courses should be strengthened in the physiotherapy department of universities or colleges, and a lot of professional cardiopulmonary therapists should be trained after their graduation [19]. However, there was a significant difference between smokers and non-smokers at the initial measurement of FVL, but there was no significant difference thereafter. This is thought to be the result of differences between the methods of FBE and BBE, and in previous studies, BBE was mentioned more effectively in some items than FBE [20]. However, further studies are recommended to be more accurate. Rectus abdominis showed significant difference in the measured values from beginning to end. This is different from the FBE group in this study. However, it can be explained that they did not find any significant difference between smokers and non-smokers.

The limitation in this study is the relatively short intervention period from four weeks, which does not fully reflect the characteristics of the elderly. In addition, it is difficult to generalize to the whole people in South Korea because this study chose the elderly in some regions. The agonist muscle of respiration is a diaphragm, that the movement of the muscle is large up and down, and the measurement of the muscle activity by the rib is interrupted, so that the surface EMG analysis was impossible. In future research, we think that it will be possible to carry out a higher-quality study by applying a long-term intervention to reflect the characteristics of the elderly better and by comparing the people in the wider area. Furthermore, if we devise a method to grasp the diaphragm 's muscle activity more precisely, authors think it can bring more accurate results.

CONCLUSIONS

Overall, except for FVL, FBE and BBE failed to narrow the differences in smokers who already reduced pulmonary function by smoking compared to non-smokers. Therefore, the campaigns to reduce the smoking rate are needed constantly, and national budgets should be enforced accordingly.

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