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Respiratory Muscle Training of Pulmonary Function for Smokers and Non-smokers

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Abstract. [Purpose] The purpose of this study was to examine the effects of respiratory muscle training using feedback on respiration to prevent or mitigate the effects of a variety of respiratory disorders. [Subjects] The subjects of this study were 34 male undergraduates in their 20s (experimental group, 17; control group, 17). [Subjects and Method] The respiratory muscle training was performed for about 60 minutes, three times per week for 6 weeks. Measurements were made of forced vital capacity (FVC), peak expiratory flow (PEF), and forced expiratory volume at one second (FEV1). [Results] Prior to the exercise, the FVC value of the experimental group was lower than that of the control group. The FVC and other values of the the smokers group showed increases after the exercise. The FVE1 value of the non-smokers group showed an increase after the exercise. [Conclusions] The respiratory muscle training was proven to be effective at improving pulmonary function.
Key words: Respiratory muscle training, Pulmonary function, Twenties

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INTRODUCTION

When an organism generates energy by metabolizing substrates delivered into cells, it is important that the respiratory function draws oxygen into the lungs and discharges alveolar gas out of the body under the process in which the respiratory and circulatory systems obtain and supply oxygen to cells. Therefore, pulmonary function disorders reduce the body's oxygen supply[1)]. In order for a human to fully express his or her abilities in physical activities, each body organ should be maintained in the best condition. In particular, pulmonary function greatly affects motor ability in physical activities[2)].

Most studies regarding pulmonary function and respiration are concerned with smoking. However, the number of studies related to respiratory training has recently increased as its importance and usefulness has begun to gain attention. Previously, respiratory treatment or training was conducted only for patients with chronic obstructive pulmonary diseases such as bronchitis and emphysema, but recently, it has been extended to general pulmonary patients including those with interstitial lung diseases, cystic fibrosis, bronchiectasis, chest malformations, lung transplantation or pneumonectomy, and neuromuscular diseases[3)]. The subject range is now broad enough to cover patients with spinal cord injuries, stroke, and nerve injuries[4–7)]. Studies using respiratory training as a treatment method indicate that an improvement in respiratory function assists disease recovery. Moreover, breathing is used as a tool to measure the effectiveness of a pulmonary rehabilitation program for stroke patients, the condition of patients with spinal cord injuries, and the changes before and after exercise among middle-aged women[8–11)]. Feedback respiratory muscle training is, not only a treatment method on its own, but can also be used to measure the effectiveness of respiratory interventions.

Even though respiratory muscle training is commonly conducted for patients, few studies have examined its effects on normally healthy subjects. If breathing exercises were useful for healthy subjects, they could be used to prevent respiratory distress when there are concerns of diminishing pulmonary function due to pollution or smoking. Feedback respiratory muscle training is known to enhance chest expansion and pulmonary function by improving respiratory function, increasing workout adaptability, releasing respiratory distress[10)], and enhancing pulmonary function[11)]. This study examined the effect of feedback respiratory muscle training using a sample of male college students in their twenties with the purpose of providing basic data for the prevention of a variety of respiratory disorders.

SUBJECTS AND METHODS

The subjects of this study were 34 male undergraduates in their 20s (experimental group, 17; control group, 17) whose respiratory and cardiovascular systems were normal, who had no orthopedic problems and who were able to walk normally. The possible results of the experimental procedures and the experiment itself were explained to the

Table 1. Pulmonary function in accordance with respiration exercise

Variables	Smoker/Non-smoker	Prior to Respiration Exercise	After Respiration Exercise
FVC (L)	Non-smokers	4.47 ± 0.6**	4.34 ± 0.6
	Smokers	3.56 ± 0.7	4.26 ± 0.61**
FEV1 (L)	Non-smokers	3.64 ± 0.36	5.12 ± 0.91**
	Smokers	3.44 ± 0.72	3.64 ± 0.43
PEF (LPS)	Non-smokers	4.84 ± 1.04	5.06 ± 1.08
	Smokers	4.77 ± 0.78	4.87 ± 1.04

**: p<0.01, FVC (forced vital capacity), FEV1 (forced expiratory volume in 1 second), PEF (peak expiratory flow)

subjects prior to their participation in this experiment and they signed a written consent indicating their voluntary participation.

The experimental group consisted of smokers whose average ages, heights and weights were 23.1 ± 1.8 years old, 175.1 ± 4.5 cm and 75.7 ± 15.5 kg, respectively. The experimental group's average daily cigarette consumption was 30 cigarettes and their average duration of smoking was 5 ± 2.6 years old. The control group was composed of non-smokers and their average ages, heights and weights were 22.0 ± 1.6 years old, 174.8 ± 7.5 cm and 73.5 ± 10.7 kg, respectively. The experiment ran from March to April 2011. Respiratory training was performed three times per week for 6 weeks: a total of 18 times. Each subject performed 3 sets of respiratory muscle training consisting of 15 minutes training followed by 5 minutes rest, with each session lasting about 60 minutes. Performance and measurement of the experiments took place in an exercise therapy room at Youngdong University. The method of respiratory muscle training and how to perform it was explained to the participants in detail. The subjects exhaled and inhaled through the mouthpiece of a spirometer, Spiro Tiger (ST medical, Swiss), while watching the monitor. The spirometer, Spiro Tiger, was adapted with a device we developed ourselves, consisting of tubing that connects a rebreathing bag to a mouthpiece. In the middle of this tubing, there is a sideport. This sideport contained a valve and a 6-mm hole to allow inspiration and expiration of ambient air: it also contains a valve. Subjects fill and empty the rebreathing bag completely while obtaining additional fresh air through the small hole during inspiration and partially breathing out through the small hole during expiration. To assure a constant tidal volume, the valve inserted in the sideport closes when subjects empty the bag completely during inspiration and inspiratory air passes purely through the sideport[12]. Subjects wore a nose clip so that they inhaled and exhaled only through this equipment. The base station was manipulated by the researcher who pressed the start button. Watching the monitor, the subject breathed out when the bar reached the position of "in" and breathed in when the bar reached the position of "out". The equipment's display and acoustic feedback were crucial because they enabled the subjects to breathe within their isocapnic threshold. Those who felt fatigue or dizziness stopped training and rested before resuming the exercise[2]. Each participant's vital capacity was measured using a CardioTouch 3000 ECG (Bionet, Korea)[13]. Subjects relaxed in a standing position for five minutes so that they felt stable and had a regular respiratory pattern. The measurement was made two hours or longer after a meal. Smokers were forbidden to smoke two hours before the experiment, so that pre-experimental smoking did not affect their vital capacity or maximal oxygen uptake. Subjects were educated on spirometer use and abdominal breathing. Forced vital capacity (FVC) was selected from the test menu and the program was implemented. Subjects held the mouthpiece in the mouth with the nose blocked and conducted tidal breathing three times. When respiration stayed constant, subjects inhaled air to the maximum level and exhaled air as fast and strongly as possible, then inhaled again when the air within the lungs had been discharged to the residual volume[1]. Measured items included FVC, forced expiratory volume in 1 second (FEV1), and peak expiratory flow (PEF). Correct performance of the exercise was identified by the air flow and respiration state on the screen. For greater reliability, measurements were taken at least 3 times and the average maximal value was used for analysis. Measurement was made prior to and after the respiratory muscle training.

RESULTS

The results of respiratory muscle training on pulmonary function are as follows. Prior to the exercise, the FVC value of the smokers group was significantly lower than that of the non-smokers group ($p<0.01$). However, the FEV1 and PEF value did not differ between the two groups. The FVC value of the non-smokers group did not change significantly between before and after the exercise, but that of the smokers group showed a statistically significant increase after the exercise. The FEV1 value of the non-smokers group showed a statistically significant increase between before and after the exercise, but those of the smokers group did not change significantly after the exercise. The PEF values were not significantly different between before and after the exercise in both groups (Table 1).

DISCUSSION

Much research has been done on the harmful effects of smoking on pulmonary function, but how exercise can improve smokers' pulmonary functions has not been sufficiently explored. Accordingly, this study looked at the effects of respiratory muscle training using feedback on the pulmonary function of smokers and non-smokers.

The intake oxygen and discharge carbon dioxide by the lungs are essential functions for the activation of body energy sources, which takes place at the beginning and ending of the human body's energy metabolism[1]. The close relationship between pulmonary function impairment and smoking is widely known. Research has shown that smoking decreases cardiopulmonary function[11] and smokers have decreased pulmonary function, as shown by items such as FEV[14]. Our results confirm that smokers have lower FVC values than those of non-smokers, which is consistent with prior study results[15]. After the respiratory muscle training, only the smokers' FVC values increased. Prior studies of pulmonary function among asymptomatic smokers have reported significant impairment of almost all parameters of lung function, especially those indicating airway obstruction. Also, increasing cigarette consumption is reported to be associated with a progressive reduction in mean flow rates and an increase in the incidence of severe obstruction[16]. This suggests that the non-smokers' FVC levels did not change because they had healthy respiratory functions and the respiratory exercise was solely effective for the smokers who had impaired FVC.

In general, FEV1 tends to decrease with age and in patients with diseases like asthma involving increased airway resistance[1]. Whereas FVC shows restrictive ventilatory impairment, FEV1 can be used to evaluate the degree of obstructive ventilatory impairment; the FEV1/FVC ratio can be used to identify obstructive ventilatory impairment[17]. In this study, the smokers group's FEV1 levels were lower than those of the non-smokers group and only the non-smokers group showed a significant improvement in FEV1 after the training. Therefore, smokers are more likely to be exposed to respiratory tract diseases. Particles in smoke cause vagal reflex through mechanical stimulation, resulting in simultaneous bronchial contraction in the small and large airways. Moreover, the smoking particles inhaled do not easily reach the alveoli and therefore many of them accumulate in the airway[15].

This study had some limitations in that the smokers were included in the experimental group en bloc, without distinguishing subgroups by the age at which they began smoking, or the frequency or volume of smoking. Therefore, a more precise analysis is desirable. To sum up the result of this study, respiratory muscle training using feedback was conducive for enhancing pulmonary function.

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