



Original Article

Effects of high intensity aerobic exercise on treadmill on maximum-expiratory lung capacity of elderly women

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Abstract. [Purpose] The aim of this study was to examine whether a systematic high intensity aerobic exercise on treadmill was effective in improving pulmonary function. [Subjects and Methods] The subjects of this study were 22 healthy elderly women over 65 years of age who were attending the Senior Welfare Center and Social Welfare Center programs in B city. For the pulmonary function test, a spirometry (Pony FX, COSMED Inc., Italy) was used. The item for measurement of pulmonary function in elderly women was maximum-effort expiratory spirogram (MES). The pulmonary function test was performed 3 times, and its mean value was used for analysis. After a 15 minute warm-up stretching, high intensity aerobic exercise was performed for 20 minutes as a main exercise, followed by 15 minutes of cool-down stretching. Exercise was performed three days a week for 12 weeks. [Results] Among items of maximum-effort expiratory spirogram, a significant difference after exercise was demonstrated in forced vital capacity, forced expiratory volume in 1 second. Two factors were improved after exercise. [Conclusion] The results demonstrated that high intensity aerobic exercise on the treadmill has a positive effect on the pulmonary function of elderly women.

Key words: Elderly women, Pulmonary function, High intensity aerobic exercise

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INTRODUCTION

As of 2015, the senior citizens' population in Korea was about 13.2% of the total population, which represented an increase of about 2% compared to that of 2010 when it was about 11.3%¹⁾. An increase in the elderly population is desirable as it provides evidence that life expectancy is increasing. According to the National Statistical Office (NSO) of Korea¹⁾, 89.2% of the 65 year-old population had one or more chronic diseases as of 2015. In addition, the number of deaths of 65 year-old elderly people per 100,000 population was highest in cancer (820 persons), second in cardiovascular disease (757.6 persons), and third in respiratory disease (393.9 persons). On the other hand, since 2010, the mortality rate due to cancer and cerebrovascular disease has decreased, but the mortality rate of heart disease, pneumonia and diabetes mellitus have been increasing. In particular, respiratory diseases are becoming more and more common because of air pollution, micro dust, and so on.

The main treatments for lung disease are medication and surgery. Thus, most studies have examined the effects of medication and surgery on lung disease. Corticosteroids and carbapenems are effective for restricting pulmonary disease (RPD)²⁾. In the case of chronic obstructive pulmonary disease (COPD), beta-adrenergic agonists, anticholinergics, methylanthines, corticosteroids and LABA are known to be effective³⁾. It has also been reported that surgery has reduced mortality in inflammatory lung disease⁴⁾. As a result, medication and surgery are positive treatments for chronic lung disease. However, since

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medication or surgery is performed after the onset of disease, they are of limited value in prevention. Therefore, there is increasing interest in exercise programs that can improve pulmonary function and prevent respiratory disease, and recent studies have researched the effect of exercise on pulmonary function. Dance exercise⁵⁾, gate ball exercise⁶⁾, and core muscle exercise⁷⁾ have been reported to have a positive effect on pulmonary function enhancement in the elderly. Thus, most studies show that exercise has a positive effect on pulmonary function improvement. However, even though pulmonary function is influenced by aerobic exercise, which can be repeatedly accomplished by lung expansion and contraction, previous studies have included many anaerobic factors that relax or strengthen muscles. Therefore, it is necessary to study the effect of aerobic exercise on pulmonary function.

Hence, in this study, we researched whether a systematic high intensity aerobic exercise on treadmill was effective in improving pulmonary function.

SUBJECTS AND METHODS

The subjects of this study were elderly women attending the Senior Welfare Center and Social Welfare Center programs in B city. All subjects fully understood the purpose and methods of the study, which complied with the ethical standards of the Declaration of Helsinki. This study had approval of the Ethics Committee of Silla University (Approval Number: 1041449.201606.HR.004). Written informed consent was obtained from each participant. Among the elderly women who wanted to participate in this study, those who could not exercise regularly due to musculoskeletal disease, those who participated in regular exercise twice a week (at least once 20 minutes) within 3 months as of the start of the study, and those who had experienced cardiovascular disease and psychotic illnesses were excluded from the study. Twenty-two elderly women who met the criteria of this study were selected as final study subjects. The mean age of the subjects was 70.7 ± 3.8 years, height was 153.8 ± 4.3 cm, body weight was 56.2 ± 7.2 kg and BMI was $23.7 \pm 2.4\%$.

To determine the exercise intensity, the submaximal exercise test was performed using Treadmill (Series 2000, Marquette Electronics, USA). The Bruce protocol for high-risk group was applied in consideration of the physical ability of the subjects⁸⁾. This test has the advantage of providing a safe examination in which the elderly can comfortably respire and move while being examined. Based on ACSM⁹⁾, maximal HR (heart rate) was defined as HR when the heart rate did not increase even though the exercise intensity increased during the test, or as HR when the rating of perceived exertion (RPE) was 17 and over. Based on the maximal HR of the elderly, this study defined 70% as a high intensity exercise, continued for 20 minutes. After a 15 minute warm-up stretching, high intensity aerobic exercise was performed for 20 minutes as a main exercise, followed by 15 minutes of cool-down stretching. Exercise was performed three days a week for 12 weeks.

Pulmonary function tests were performed with a digital spirometer (Pony FX, COSMED Inc., Italy). The items to be measured in the experiment were Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 second (FEV_1), FEV_1/FVC , Maximal Expiratory Flow 75% (MEF 75%), Maximal Expiratory Flow 50% (MEF 50%), and Maximal Expiratory Flow 25% (MEF 25%). Pulmonary function tests were taken while the subjects were in a straight sitting posture on a chair. The subject's waist and shoulders were straight. Legs were opened to the width of the subject's shoulders, and feet were placed vertically on the floor¹⁰⁾. The measurements were performed 3 times and the mean value was used for the analysis. The general characteristics of the subjects were assessed using descriptive statistics and the mean and standard deviation. Before and after exercise, paired t-test was performed to evaluate pulmonary function changes. The statistical analysis program used in this study was SPSSWIN (ver. 23.0) and the significance level was $\alpha=0.05$.

RESULTS

The effects of high intensity aerobic exercise for maximum-expiratory lung capacity are shown in Table 1. FVC was 2.1 l before exercise and improved significantly to 2.3 l after exercise ($p<0.05$). FEV_1 was 1.7 l before exercise and improved significantly to 1.8 l after exercise ($p<0.05$). On the other hand, FEV_1/FVC was 81.1% before exercise and decreased to 80.2% after exercise, but there was no statistical difference. In addition, MEF 75% increased from 4.1 l to 4.2 l after exercise, while MEF 50% did not change from 2.3 l to 2.3 l, and MEF 25% decreased from 0.8 l to 0.7 l, but there was no statistical difference (Table 1).

DISCUSSION

In general, pulmonary function declines with age¹¹⁾. Treadmill aerobic exercise has been recommended as a way to maintain or improve pulmonary function¹²⁾. Exercise on the treadmill is an aerobic exercise that requires a large amount of oxygen uptake because of the long-term use of muscles¹³⁾. Nevertheless, there is a lack of research into the effects of aerobic exercise on pulmonary function. Therefore, this study researched the effect of high intensity aerobic exercise on treadmill on the maximum-expiratory lung capacity of elderly women. In the results, FVC significantly improved after high intensity aerobic exercise. In other words, vital capacity increased after high intensity aerobic exercise. Lee et al.¹⁴⁾ also reported increased FVC in the middle-aged group after treadmill exercise. Ericson et al.¹⁵⁾ reported that aerobic exercise on treadmill for elderly subjects increased VO_2 max. It suggests that high intensity aerobic exercise increased the oxygen uptake and

Table 1. Changes of maximum-expiratory lung capacity after high intensity aerobic exercise

Variables	Pre-exercise	Post-exercise
FVC (l) *	2.1 ± 0.4 ^a	2.3 ± 0.5
FEV ₁ (l) *	1.7 ± 0.4	1.8 ± 0.3
FEV ₁ /FVC (%)	81.1 ± 5.9	80.2 ± 4.9
MEF 75% (l)	4.1 ± 1.2	4.2 ± 1.0
MEF 50% (l)	2.3 ± 0.7	2.3 ± 0.5
MEF 25% (l)	0.8 ± 0.2	0.7 ± 0.2

^aMean ± SD. *p<0.05

FVC: forced vital capacity; FEV₁: forced expiratory volume in one second; MEF: maximum expiratory flow

activated inactive alveoli, and repeated stimulation of inspiration and expiration increased alveolar compliance. As a result, FVC increased. As more inactive alveoli were activated, more air could enter the alveoli, and increased alveolar compliance could be attributed to increased lung elasticity and more air expiration. FEV₁ is a typical index of resistance to air flow in the respiratory tract¹⁶). In this study, FEV₁ increased significantly after high intensity aerobic exercise. This means that high intensity aerobic exercise improves air flow in the respiratory tract. Kang¹⁷) reported that when a large lung volume is provided, the lung is greatly expanded and has a large contractile force, and the diameter of the respiratory tract is widened to reduce air flow resistance. Therefore, in this study, we can conclude that FEV₁ is improved because the lung is expanded through high intensity aerobic exercise and a larger volume of air is introduced into the airways and the respiratory tract is widened as a result. FEV₁/FVC is known to be an indicator of airway obstruction¹⁸). Song & Kim¹⁹) researched the effect of exercise on FEV₁/FVC and reported that the enhancement of respiratory muscles and trunk muscles and the improvement of rib cage movement had a positive effect on FEV₁/FVC. However, in this study, FEV₁/FVC seemed to decrease slightly after exercise, but there was no statistical difference. This result suggests that the exercise used in this study was not a muscle strengthening exercise or a rib cage expansion exercise, but a direct stimulating exercise for alveoli with high intensity aerobic exercise. In addition, it can be considered that FEV₁/FVC was slightly decreased because FVC increased proportionally slightly more than FEV₁ after high intensity aerobic exercise. MEF is known to be an indicator of the elasticity and the degree of bronchiole resistance of the alveolar²⁰). In this study, after high intensity aerobic exercise, MEF 75% increased from 4.1 l to 4.2 l, MEF 50% did not change from 2.3 l to 2.3 l. Although MEF 25% decreased slightly from 0.8 l to 0.7 l, there was no statistical difference. These results suggest that a large amount of air was discharged in the early stage of the expiration period and the amount of air remaining in the bronchiole decreased with time. As a result, high intensity aerobic exercise may stimulate alveoli and improve lung elasticity.

In conclusion, high intensity aerobic exercise on the treadmill has a positive effect on the pulmonary function of elderly women. On the other hand, further studies are needed to determine the effect of low intensity or moderate intensity aerobic exercise on the pulmonary function.

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