



Original Article

The change of lung capacity in elderly women caused by life span

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Abstract. [Purpose] Although lung capacity in the elderly is affected by age, little research has been performed studying decreasing lung capacity in relation to increasing life expectancy. The aim of this study was to examine the effects of increased life span on the lung capacity of women. [Subjects and Methods] The subjects of this study were 55 healthy elderly women over 60 years of age who were living in Busan. Subjects were classified in the following age categories: 60s, 70s and 80s. 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. [Results] Among items of maximum-effort expiratory spirogram, a significant difference according to age was demonstrated in forced vital capacity, forced expiratory volume in 1 second, peak expiratory flow, maximum expiratory flow 75%, maximum expiratory flow 50%, and inspiratory capacity. [Conclusion] According to this study, lung capacity decreases remarkably as age increases. In conclusion, a continuous exercise program beginning at an early age is essential to prevent decrease in lung capacity as age progresses.

Key words: Lung capacity, Elderly women, Life span

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INTRODUCTION

Improved medical technology and improved standard of living are accelerating the increase of the senior citizens population¹⁾. According to the data of the National Statistics Office of Korea²⁾, the ratio of senior citizens' population stood at 13.1% in 2015, and is forecast to rise to 20.8% in 2016 and 30.1% in 2037. The increase of the aged population has produced a positive effect—the increase of the average life expectancy. On the other hand, the negative effect is that there is a large number of elderly who are suffering from the increase of chronic disease, which results in a lower quality of life³⁾. Therefore there has been increasing interest in maintaining good health and improving the quality of life¹⁾. This is particularly significant according to the research about mortality from respiratory disease. Among people aged 60 and over, 22.6 per 100,000 have chronic respiratory disease, which was the fifth major cause of death, and it has been on the rise⁴⁾. As a result, interest in chronic obstructive pulmonary disease (COPD) has been increasing recently. Research shows that for the elderly who have COPD, as breathing difficulty increases, fear of death and symptoms of depression increase, which causes a decline in the quality of life⁵⁾. Breathing difficulty is the most serious symptom for patients with COPD, which is especially life-threatening⁶⁾. The decrease of functional capacity from breathing difficulties⁷⁾ and motor disturbance⁸⁾ lower the quality of life drastically. Additional research comparing healthy people to patients with COPD has also demonstrated a lower standard of life related to health among those suffering from impaired lung function⁹⁾. In addition, social and economic expenses caused by COPD are forecasted to rise steadily¹⁰⁾, demonstrating the need to take additional measures to improve lung function.

Accordingly, most research has been focused on improving pulmonary function. Shin¹¹⁾ examined the effects of walking

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exercise programs on cardiopulmonary function in female seniors. As a result, maximum oxygen intake, heart rate, relaxed blood pressure, and maximum forced vital capacity have improved as they were stabilized. More recently, Kang et al.¹²⁾ demonstrated how a 12 week complex exercise training program affects cardiopulmonary function and the risk factor of metabolic syndrome of elderly persons who live in the countryside. In their study, maximal voluntary ventilation (MVV) has increased significantly in the group who performed a resistant workout and walking program. VO_2 max and MVV both increased meaningfully in the group that performed aerobic and yoga exercises. Accordingly, Kang said that complex exercise must include a resistant workout, walking, aerobics, and yoga in order to improve pulmonary function in the elderly. Based on respiratory rehabilitation exercise programs improving pulmonary function on patients who have COPD (such as chronic bronchial trouble and pulmonary emphysema), research has demonstrated how exercise can be productive. Patients with general lung diseases such as interstitial lung disease, fibrous cystoma, bronchial expansion syndrome, thorax malformation, lung transplantation, pneumonectomy, and neuromuscular disease, can all benefit from exercise treatments¹³⁾.

However, results of research that has developed and applied various types of respiration rehabilitation for COPD have not been consistent. One of the reasons for the discrepancies is that the age of the participants was not taken into account when exercise programs were developed and applied. Therefore most research programs have overlooked the fact that exercise intensity depends on age. Therefore, this study was designed to find out how much pulmonary function would vary as age increases. On the basis of the results of this study, an effort was made to provide basic information on developing an exercise program that takes into consideration the age of the individual.

SUBJECTS AND METHODS

Study subjects were women over the age of sixty who were living in Busan. They were fifty-five female senior citizens who agreed in writing to take part in this study after listening to the purpose of the study. They were all non-smokers who had no history of lung disease or lung infection, and who have clear cognitive abilities on lung capacity measurement. The general characteristics are described below. In the 60–69 years age group, age on average was 64.6 ± 2.7 years; height on average was 155.8 ± 3.1 cm; and weight on average was 57.3 ± 7.2 kg. In the 70–79 years group, age on average was 74.2 ± 3.1 years; height on average was 153.5 ± 5.0 cm; and weight on average was 57.0 ± 6.8 kg. In the 80–89 years group, age on average was 81.8 ± 2.0 years; height on average was 147.2 ± 5.5 cm; and weight on average was 54.6 ± 6.1 kg. This study complied with the ethical standards of the Declaration of Helsinki, and written informed consent was received from each participant.

The measuring instrument of lung capacity used in this study was a digital pulmonary function measurement (Pony FX, COSMED Inc., Italy). This measuring instrument can check the amount and the speed of air exiting from the lungs. Maximum-effort Expiratory Spirogram (MES) was measured in this study. This MSE measurement was taken while the subject was in a straight sitting posture in 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 floor. Subsequently, the subject's nose was closed with her hand. And the measuring instrument was held with one hand and inserted between the teeth with the lips closed over the measuring instrument. After 3–4 normal breaths, the subject inhaled and exhaled quickly and deeply while the measuring instrument was in place. The subject then held her breath for six seconds. The subject was given a one-minute rest between measurements. Three measurements were taken for each subject¹⁴⁾ unless dizziness was experienced, in which case only two measurements were taken. An average of the measurements was taken for each subject for analysis. These measurements were taken at the senior citizens center.

This study was designed to demonstrate the effect on the variation of lung capacity as elderly women progress in age. An independent variable was divided into three groups: age 60 to 69, age 70 to 79, and age 80 to 89. A dependent variable was set up as seven factors from the pulmonary function tests. To examine the difference among dependent variables based on age, one-way ANOVA was performed. Every significant level for data analysis was under 5%. If a significant difference among variables was demonstrated, post-hoc test by using Scheffe was used.

RESULTS

The result of pulmonary function based on the age of normal elderly women is shown in (Table 1). A statistical difference was demonstrated among the three groups. There was a statistical difference among the groups as forced vital capacity (FVC) ($p < 0.05$), forced expiratory volume in 1 second (FEV_1) ($p < 0.05$) and peak expiratory flow 1/sec (PEF) ($p < 0.05$). In the result of post hoc analysis, FVC, FEV_1 , PEF and MEF 50% for subjects in their 70s was reduced compared to those in their 60s. Also, above all items for subjects in their 80s was reduced compared to those in their 70s. There was a statistical difference among the groups as maximum expiratory flow 75% (MEF 75%) ($p < 0.05$) and MEF 50% ($p < 0.05$). In the result of post hoc analysis, MEF 75% and MEF 50% for subjects in their 80s were reduced compared to those in their 60s. However, in case of MEF 75% and MEF 50%, there was no difference significantly between 60s and 70s, and between 70s and 80s. There was a statistical difference among the three groups regarding inspiratory capacity (IC) ($p < 0.05$). In the result of post hoc analysis, IC for subjects in their 80s was reduced compared to those in their 60s and it of 70s. But, in case of IC, there was no difference significantly between 60s and 70s.

Table 1. The changes of lung capacity in elderly women by life span (Unit)

Variables	60–69 years (N=22)	70–79 years (N=22)	80–89 years (N=11)
FVC (l)*	2.43 ± 0.32 ^{†‡}	2.11 ± 0.38 [#]	1.57 ± 0.32
FEV1 (l)*	1.98 ± 0.28 ^{†‡}	1.69 ± 0.35 [#]	1.31 ± 0.27
PEF (l)*	4.75 ± 1.19 [‡]	4.05 ± 1.43	3.07 ± 0.85
MEF 75%*	4.37 ± 1.05 [‡]	3.68 ± 1.35	2.75 ± 0.74
MEF 50%*	2.59 ± 0.7 [‡]	2.23 ± 0.88	1.75 ± 0.49
MEF 25%	0.98 ± 0.47	0.76 ± 0.29	0.78 ± 0.37
IC (l)*	1.84 ± 0.31 [‡]	1.57 ± 0.42 [#]	1.14 ± 0.38

Mean ± SD. *p<0.05

[†]60–69 year > 70–79 year, [‡]60–69 year > 80–89 year, [#]70–79 year > 80–89 year

FVC: forced vital capacity; FEV1: forced vital capacity in one second; PEF: peak expiratory flow;

MEF: maximum expiratory flow; IC: inspiratory capacity

DISCUSSION

Lung aging can cause lung problems that are exacerbated by toxins from the external environment, smoking, and respiratory infections. As the lung ages, it decreases in physiological capacity, and breathing mechanism problems occur due to limitations in chest wall movement and decreases in lung elasticity¹⁵. Furthermore, fat content and elastin in lungs decrease as age increases, breathing muscle strength weakens, and pleural elasticity and fibers decrease in length and diameter, further weakening the lungs elastic contractility¹⁶. As a result, lung tissues become stretched. Changes in age-related breathing mechanisms cause limitations in respiratory airflow, and those limitations are known to reduce the rates of FEV₁ and FEV₁/FVC in breathing function tests, which show the occurrence of air trapping and hyperventilation as well as increases in residual volume and functional residual volume¹⁷.

Song et al.¹⁸) investigated vital capacity (VC) in accordance with age among participants between the ages of 20 to 70, and they reported that as age increases, age and VC correlate negatively. Kim et al.¹⁹) also measured changes in lung function among participants divided into four groups according to age (60 to 64, 65 to 69, 70 to 75, and over 75 years of age), and reported that FEV₁, FVC, and VC decrease as age increases in all participants, both male and female, in all four groups. Abe et al.²⁰) measured VC, FEV1 and assessed their physical function and mobility in 1,022 women aged ≥75 years who were living in an urban environment, and reported older women exhibited inferior pulmonary function as well as reduced physical function and mobility. The results of this study also confirmed that FEV₁, FVC, and FEV₁/FVC decrease as age increases in participants in their 60s, 70s, and 80s, which corresponds with the results of previous studies. While previous studies did not consider measurement variables for peripheral bronchi, this study tested the numbers of MEF75%, MEF50%, and MEF25% in order to check the changes in peripheral bronchi as age increases. The study confirmed that peripheral bronchi also decrease as age increases. In these decreases in peripheral bronchi, “closing volume” speeds up, that is, the air flow closes particularly rapidly in small airways due to the decrease in lung-supporting elastic fibers. The increase in closing capacity causes a decrease in oxygen saturation because of the decrease in alveolar ventilation for lung perfusion, which is triggered by air flow closure²¹. Likewise, potential to develop breathing problems increases as age increases because of VC decrease and closure of peripheral bronchi. As before mentioned, such VC decreases in the elderly are considered to be due to decreases in breathing mechanism and to limitations in chest-wall movement. Although the lung-protective structure of the thoracic cavity is essential for normal lung functioning, it more greatly affects normal lung function as age increases due to changes in the structure of the thoracic cavity (i.e., spines, muscles, and ribs)²². Lombardi, et al.²³) confirmed VC changes in various angles of the thoracic kyphosis in 55 non-smoking women, and reported that FEV₁ and VC decreased as angles increased in pulmonary function test. Muscles also change as age increases, as does the structure. Aging is known to be highly related to decreases in inspiratory and expiratory muscle strength²⁴. According to previous studies on breathing muscle correlation, maximal inspiratory and expiratory pressures (assessments of maximal inspiratory and expiratory muscle strength) decreased in the elderly. When the mean heights and weights were compared among participants in their 50s to 80s, the mean maximal inspiratory pressure of participants in their 50s was 111 cm H₂O, and that of participants in their 80s was 70 cm H₂O, confirming a significant decrease²⁵. Age-related decreases in maximal inspiratory and expiratory pressures relate to problems in breathing mechanism and to elderly people’s sarcopenia²⁶.

The results of this study confirmed the overall VC decrease in elderly people as age increases. This age-related VC change is caused by changes in the thoracic structure and breathing muscle weakness in elderly people, as confirmed by previous studies. Therefore, if exercise programs for the elderly can be developed in accordance with age, they will help to prevent VC decreases in the elderly, and it will lead to successful aging. Additional studies are needed to develop exercise programs that are fit for the elderly in each age group and to confirm VC changes after doing the exercises.

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