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Original Article

Analysis of the influential factors of maximal-effort expiratory capacity of elderly women

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Abstract. [Purpose] The purpose of this study was to find the influential factors of maximal-effort expiratory capacity of elderly women. [Subjects and Methods] The subjects of this study were 83 healthy elderly women. The study's methods and purpose were explained and these women agreed to participate. The maximal-effort expiratory capacity was measured using spirometry (Pony FX, COSMED Inc., Italy). We measured forced vital capacity, forced expiratory volume in 1 second, forced expiratory volume in 1 second/forced vital capacity, maximal expiratory flow 75%, maximal expiratory flow 50%, and maximal expiratory flow 25%. [Results] Regarding forced vital capacity and forced expiratory volume in 1 second, it was found that height and age were influential factors. Regarding forced expiratory volume in 1 second/forced vital capacity %, maximal expiratory flow 75%, maximal expiratory flow 50%, and maximal expiratory flow 25%, it was found that only age was an influential factor. [Conclusion] This study demonstrated that the most influential factors of maximal-effort expiratory capacity of elderly women were age, and the second influential factor was height. We noticed that weight was the least influential factor among them.

Key words: Maximal-effort expiratory capacity, Influential factor, Elderly women

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INTRODUCTION

According to the National Statistical Office (NSO) of Korea, Korea became an aging society when elderly people above the age of 65 make up 13.1% of the population in 2015[1)]. The NSO of Korea expects the population of the elderly would be 14.3% in 2018[2)]. Although the increase in population of the elderly can be considered a good phenomenon in terms of lengthening lifespan, there is room for improvement in terms of satisfactory life quality. Korea Institute for Health and Social Affairs (KIHSA) surveyed the life satisfaction among the elderly in 2014 and its result shows that 29.5% are satisfied, 26.2% are mediocre, and 44.2% are not satisfied with their life quality[3)]. As the statistics show the rate of dissatisfaction is relatively high. Self-evaluation of one's health condition is one of the most influential predictable factors for the life satisfaction index of the elderly[4)]. Regarding this aspect, KIHSA reported that 90.4% have more than one chronic illness requiring a long term treatment and recuperation and 72.2% have more than two chronic diseases among the elderly population. It is noteworthy that 32.4% thought they were healthy and 43.7% thought they were not healthy[3)]. These statistics show the relationship between life satisfaction and health. Therefore, there has been an increase of concern and interest in healthy older age above 65 coupled with an interest for longevity. The interest in healthy older age gives rise to the necessity for improvement in cardiopulmonary function and cardiopulmonary capacity. The physical fitness test is used for a pivotal physiological

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indicator of physical activity performance, together with body composition, muscular strength and flexibility to evaluate physical fitness[5]. In general, pulmonary function declines as morphological alteration occurs because of reduced elasticity of pulmonary alveoli and multiplied emphysema in the aging process[6]. The research of Americans showed that pulmonary function of men rose until the age of 27 and then declined, and that of women rose until the age of 20 and then declined[7]. Especially the drastic decline of pulmonary function starts after the age of 60, so it has been known that even though a person enjoys normal health condition, he can suffer from dyspnea occurring frequently while engaging in some exercises[8]. Consequentially, many research papers show close relativity between age and pulmonary function[9]. However, well-known prediction formula of pulmonary function test includes weight and height in addition to age[10]. In general, a decline of cardiopulmonary function causes decrease of basal metabolic rate, which can be one reason for obesity[11]. In turn, obesity can increase risk of cardiovascular disease[12], hence, weight can be one of the influential factors for cardiopulmonary function. Kim et al.[5] confirmed the relationship between weight and cardiopulmonary function in the study of senior high school male students. The relationship between height and cardiopulmonary function can be referred in the study conducted by Rode and Shephard[13]. The Caucasian Americans and the Inuit subjects featured relatively short height, and the study concluded that the Inuit had similar pulmonary function with tall height Americans since the Inuit had well developed upper body. Namely, this study shows that the pulmonary function is relatively proportionate to one's height, however, the well-developed upper body can affect the pulmonary function as well. Per contra, most of the studies were conducted with young age subjects, so it is necessary for the study to be conducted with elderly subjects to examine their physical features affecting the pulmonary function. Therefore, this study purposes to recognize how physical features such as age, weight and height can affect the pulmonary function and to provide useful basic data for the programs to enhance the pulmonary function of the elderly.

SUBJECTS AND METHODS

The subjects were the elderly of S university's lifelong education center and senior community centers of Jurae and Kangsundae in Busan. The subjects were 83 elderly women agreed to participate, able to move freely, having no history of respiratory disease, no difficulty in breathing and non-smokers. This study complied with the ethical standards of the Declaration of Helsinki, and written consent was received from each participant. The physical features of the subjects were: age on average 71.0 ± 8.6 years, height on average 153.6 ± 5.9 cm, and weight on average 57.0 ± 6.8 kg.

The measuring equipment for the pulmonary function used in this study was spirometry (Pony FX, COSMED Inc., Italy). This equipment can measure the speed and quantity of air flowing in and out of the lung. We checked and measured forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1), FEV_1/FVC, maximal expiratory flow 75% (MEF 75%), MEF 50%, and MEF 25%. As the accuracy of measurement of pulmonary function is dependent on the examinee's cooperation and effort, the purpose and significance of the study were informed and the participants were told of the measurement method and ways. They were asked to stand on their feet which were spaced as wide as their shoulder and vertically grounded with their straightened shoulders and back[14]. The measurement was performed 3 times at each session, and the mean value was used for analysis. The purpose of this study was to examine the influential factors affecting the pulmonary function of elderly women. Hierarchical regression analysis was performed in this study to check how age, height, and weight which were known as having linear relations with the pulmonary function, can affect the pulmonary function. We used the SPSSWIN (ver. 23.0) for statistical analysis and a significance level of $\alpha=0.05$.

RESULTS

Table 1 shows the results about the influential factors of Maximal-effort expiratory capacity. Regarding FVC and FEV_1, it was found that weight was an influential factor in two variables of the model 1 ($p<0.05$). However, not weight but height ($p<0.05$) was an influential factor in the model 2 which was added with height factor. Not weight rather height ($p<0.05$) and age ($p<0.05$) were influential factors in the model 3 which was added with age factor. Furthermore, age was found to be more influential than height. Therefore, it was observed that FVC and FEV_1 were the most affected by age, less affected by height, and not affected by weight.

Regarding FEV_1/FVC%, it was observed that weight was not an influential factor in model 1. In model 2, which was model 1 added with height factor, neither weight nor height affected pulmonary function. In model 3, which was model 2 added with age, age ($p<0.05$) was an influential factor, whereas neither weight nor height was. Consequently, it was found that the function of FEV_1/FVC% is affected by the age factor. Regarding MEF 75%, MEF 50%, and MEF 25%, model 1 showed that weight wasn't an influence in all the variables. In model 2, which was model 1 added with height, height ($p<0.05$) was an influential factor, whereas weight was not. In model 3, which was model 2 added with age, age ($p<0.05$) was found to be an influential factor, however, neither weight nor height was. Hence, it was found that the function of all MEF% is affected by age, not by weight or height.

Table 1. An analysis of the influential factors of maximal-effort expiratory capacity (Unit)

Variables		Model 1			Model 2			Model 3		
		SE	β	t	SE	β	t	SE	β	t
FVC (l)	Weight	0.008	0.240	2.224*	0.007	−0.082	−0.913	0.006	−0.003	−0.043
	Height				0.008	0.724	8.026*	0.009	0.397	3.746*
	Age							0.006	−0.454	−4.734*
FEV1 (l)	Weight	0.007	0.252	2.348*	0.006	−0.027	−0.270	0.006	0.067	0.766
	Height				0.007	0.627	6.371*	0.008	0.239	2.128*
	Age							0.005	−0.537	−5.268*
FEV1/FVC (%)	Weight	0.155	0.032	0.289	0.174	0.005	0.044	0.165	0.093	0.788
	Height				0.199	0.060	0.481	0.244	−0.305	−1.992
	Age							0.154	−0.506	−3.646*
MEF 75 (%)	Weight	0.022	0.118	1.070	0.023	−0.080	−0.700	0.021	0.013	0.121
	Height				0.026	0.444	3.907*	0.031	0.061	0.448
	Age							0.019	−0.531	−4.312*
MEF 50 (%)	Weight	0.015	0.193	1.774	0.016	0.049	0.421	0.015	0.145	1.339
	Height				0.018	0.324	2.767*	0.021	−0.073	−0.521
	Age							0.013	−0.550	−4.342*
MEF 25 (%)	Weight	0.006	0.045	0.408	0.006	−0.073	−0.604	0.006	0.001	0.009
	Height				0.007	0.266	2.198*	0.009	−0.042	−0.279
	Age							0.006	−0.428	−3.108*

*$p<0.05$

DISCUSSION

Schoenberg et al.[8] explained that they found in their study that age, gender, and weight were influence factors of pulmonary function, especially as weight increased, the muscle strength improved, so it led to strengthening pulmonary function. However, if weight kept increasing to the point of obesity, the movement of thorax came to reduce, and it led to a decline of pulmonary function. In other words, there was close relationship between weight and pulmonary function. However, Quanjer[15] and Degroodt et al.[16] mentioned that the most influential factor for pulmonary function was height in the case of children and adolescents, even though age, weight, and height were influential factors, because children and adolescents grew fast in their height and their respiratory capacity changed accordingly. In addition to this, Hwang and Shim[17] reported that vital capacity (VC) and FVC declined significantly as age advanced. On the other hand, Lee et al.[18] reported that FEV_1 and FVC increased significantly as age and height grew. These studies and reports show that age, weight, and height affect the pulmonary function.

However, all these previous studies have a limitation since they didn't take into account the correlation among the influential factors such as age, weight, and height, even though they examined how age, weight, and height affected the pulmonary function respectively. Hence, this study aimed to check the influential factors of the pulmonary function in relationship to age, weight and height. The experiment showed that if weight was considered as a variable alone regarding FVC and FEV_1 which were understood to be related to the function of large airway, they were affected by the weight factor, however, if weight and height were considered as variables, they were affected only by height. However, if age, weight, and height were considered together, then the pulmonary function was affected by age and height, but not by weight. Furthermore, the pulmonary function was more affected by age than height. Nevertheless, the function of FVC/FEV_1% was affected by neither weight nor height but only by age. Regarding the function of MEF 75%, MEF 50% and MEF 25% which were known as related to the function of small airways, weight couldn't affect them, even though weight was considered as a single variable. However, when weight and height were considered together, height was found to be an influence factor. Furthermore, it was found that when age, weight, and height were considered together, neither weight nor height but only age could affect the pulmonary function. These results show that the pulmonary function of large airways is affected by age and height in the case of elderly women, however the function of small airways is affected by age only. Therefore, the pulmonary function of elderly women gets affected most greatly by their age. The results of this study are similar to the results of study done by Janssens[9] which reported that the pulmonary function declined as age advanced. The decline of the pulmonary function can be considered to be related to the aging process. In general, as aging progresses, the respiratory system goes through changes, because the elasticity of pulmonary alveoli and alveolar ducts reduce. The decrease of elastic properties of cells causes emphysema, imbalance of ventilation-perfusion, decrease of surface area per lung volume, and in turn, dyspnea. In addition, as aging progresses, osteoporosis of the ribs, calcification of costal cartilage, increase of stiffness of rib cage, respiratory muscle weakness, and imbalance of inspiratory and expiratory pressures occur, and in turn, these changes tend to cause more decline of the pulmonary function[19–21]. Therefore, the results of this study are considered to be a phenomenon showing the reason why the pulmonary function declined because the function of pulmonary alveoli, airways and respiratory system were weakened in the aging process.

However, this study was conducted with the elderly women aged above 65 years only, so the study has limitation and should expand its results to other age groups. Furthermore, although it was reported that fat distribution in the upper body reduced the pulmonary function[22, 23], this study didn't consider the distribution rate of fat in the upper body and this could be viewed as a shortcoming of this study. Chen et al.[24] pointed out that if weight was to be considered as a single variable, body fat and muscle mass could not be considered separately, and this could hinder from finding relationship between weight and pulmonary function. In addition to this, the elderly suffer from the weakening musculoskeletal system, and this causes their head to bend down outwardly and their cervical spine and lumbar spine to have less curve, and in turn, it leads to spine retroflexion[25]. Besides, strength and endurance of the respiratory muscles decline and the muscle strength of diaphragm declines by 25% as the postural change and body frame becomes smaller as aging advances[26]. As the facts are considered that the lung has passive elastic properties and is located inside the rib cage, and air flow in and out of the lung is made by respiratory muscles[27], the weakening of respiratory muscles, diaphragm and pelvic floor muscle and other muscles can greatly affect pulmonary function.

Therefore, even though it is difficult to recognize how the change of height of the elderly affects pulmonary function alone, this study has a limitation by not including these aspects. Hence, there is a necessity of research to see how the distribution rate of fat in the upper body of elderly women, deformation of body structure, and the function of respiratory muscles can affect the pulmonary function in the future.

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