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Effect of a Respiratory Training Program Using Wind Instruments on Cardiopulmonary Function, Endurance, and Quality of Life of Elderly Women

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Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
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Background: Physical changes due to aging lead to weakening of respiratory muscles and decreased lung functions that result in increasing risk of chronic respiratory disease. A complex respiratory rehabilitation program is needed to prevent respiratory diseases and improve lung functions and quality of life. The purpose of the present study was to examine the effects of respiratory training programs on pulmonary functions, cardiovascular endurance, and quality of life in elderly women.

Material/Methods: The program was structured with respiration exercise and playing wind musical instruments for 10 weeks (n=13) and 5 weeks (n=16), respectively, for elderly women in 2 different community welfare centers. The program consisted of breathing exercises twice a week, 20 min per session, and 40 min of wind instrumentation. Effects were assessed using forced vital capacity (FVC), forced expiratory volume-one second (FEV1), FEV1/FVC ratio (FEV1%), maximum voluntary ventilation (MVV), 6-minute walk test (6MWT), modified Borg scale (MBS), and life satisfaction scale (LSS).

Results: The 10-week program group (10WPG) showed significant differences in FVC, MVV, 6MWT, MBS, and LSS before and after interventions ($p<.05$), and the 5-week program group (5WPG) showed significant differences in FVC and 6MWT. MVV, MBS, and LSS were not significantly different between the 2 groups ($p<.05$).

Conclusions: This study confirms that the long-term respiration training program has positive effects on pulmonary functions, cardiopulmonary endurance, and quality of life. Various respiratory training programs and long-term implementations are needed to prevent respiratory illness and to improve lung functions and quality of life of respiratory patients.

MeSH Keywords: **Aged • Breathing Exercises • Pulmonary Ventilation • Respiration**

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Background

The population of people over 65 years of age in Korea was 4.6 million (9.5%) in 2006, 6.76 million (13.2%) in 2015, and is expected to reach 10.5 million (20.0%) in 2025, making a super-aged society. The ratio of the elderly women in 2015 was approximately 57%, surpassing the population of men [1]. As the life expectancy increases, the numbers of patients with chronic adult diseases are also increasing. The rank of mortality by respiratory diseases in 2006 was 5th and has increased to 3rd in 2015, creating a social concern about chronic respiratory diseases [1]. In particular, the number of deaths due to respiratory diseases in elderly women has steadily increased over the last 10 years, reaching 50 per 100 000 people by 2016 [2].

The decrease of elastic tissues around the alveoli and alveolar duct due to aging decreases the surface area per lung volume, and thoracic stiffness increases due to osteoporosis of the costal bones and calcification of costal cartilages. In addition, weakening of the respiratory muscles results in limitation of the thoracic during inspiration and decline in vital capacity, and this leads to higher risk of lung diseases and decrease in cardiopulmonary functions [3]. The increase of chronic respiratory diseases in the elderly impacts the national medical budget, economic loss from not being able to sustain a normal life, limitations in emotional activities, and mortality rate. Therefore, there is a need for a program that prevents respiratory diseases, promotes lung functions, and increase quality of life [4].

Various studies have been conducted on physical therapy interventions for improving respiratory function, such as core exercise, walking exercise, respiratory muscle strengthening training, complex breathing exercise, and other training programs [5–7]. Among respiratory muscle training interventions, diaphragm breathing is the most common method of training [8]. Simultaneous stabilization of the lumbar from transversus abdominis and harmonious contraction of the diaphragm are an effective method for enhancing respiration functions and maintaining proper body positions [8]. In addition, the process of breathing in deeply with the nose and exhaling slowly through pursed lips decreases the difference between the outside air and internal pressure of the alveoli, making expiration more effective by decreasing the current velocity and airway resistance [9]. This diaphragm respiration method has been applied to respiration training methods by using blowing out candles, blowing balloons, blowing bubbles, and the use of incentive spirometers [10]. However, elderly people often find these exercise methods uninteresting, and this leads to only occasional performance and not being able to receive feedback for incorrect performance. Therefore, there is a lack of expectations for long-term effects and satisfying the participants' sense of accomplishment.

Wind instruments are musical instruments in which sound is made be vibrating the air blown through the tube. After an inhalation, air is blown inside the tube, and the instrument is played by fingering, depending on the form of the instrument. While playing a wind instruments a quick yet deep inhale is followed by a long exhale with pursed lips, suggesting an effective respiratory training method by naturally applying abdominal breathing and pursed lips [11,12]. In contrast to previous studies, respiration training through playing wind instruments motivates the participants, and there is an expectation of engaging in leisure activities and improving respiratory functions. Therefore, this study investigated the effects of playing wind instruments on cardiopulmonary function, cardiopulmonary endurance, and quality of life of elderly women, and recommends an effective respiratory function enhancement program.

Material and Methods

Participants

This study recruited 20 elderly women each from Y and D community centers located in city D. The inclusion criteria were age over 65, score of 24 or greater in the Korean version of Mini-Mental Status Examination (MMSE-K), and able to independently walk for more than 6 min without any assistive device. We excluded participants who were on antipsychotic medication or who had chronic cardiac or respiratory diseases, osteopathic disease that could affect the result of the measurement, or difficulty in communicating, and anyone who participated in less than 70% of the program. Prior to the trial, all participants were given explanations of the study purpose and process, and only the participants who understood and voluntarily agreed were included in the study. This study was approved by the Research Ethics Committee of Daejeon University.

Procedures

This study is a nonequivalent pretest-posttest study design, where the participants were not provided with information on which group they were in, and the assessors only conducted pre- and posttest assessments without any information on the participants, making it a double-blinded test.

Prior to the intervention, general characteristics of the participants were gathered. In order to compare the effects by different intervention application periods after the pretest, respiration training program using wind instruments were applied for 10 weeks in participants from Y community center and 5 weeks for those at D community center. The wind instrument chosen for the study was the ocarina, since it is easy to learn for beginners and easy to manipulate. The ocarina is a closed

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Figure 1. spirometer and pulmonary function measurement posture.

wind instrument where one blows through the mouth piece and fingers 12 sound holes. All participants in the study were provided with a plastic ocarina.

The 5-week program consisted of learning the breathing method, musical scales, fingering methods, and playing the instrument. The breathing method was learned through sessions of inhaling with the diaphragm and exhaling with pursed lips. In order to make sounds with the ocarina, the participants controlled the flow of the air and applied training for maintaining the sound for 1, 4, 6, and 8 beats during the first week. The sessions for learning musical scales and fingering methods were learning the scales and fingering methods along with the already familiar breathing method. The participants practiced by repeating accurate fingering and controlling the strength of the exhalation to play the correct sounds of each scale. In the playing session, the participants used correct breathing patterns to play songs from easy to gradually more difficult. Easy children's songs and elderly-friendly folk songs were categorized by difficulty by an ocarina instructor. In the 10-week program, were added 5 additional weeks that consisted of breathing vibrato training and playing music. The 2 groups all held a recital at the end of the program to give motivation for participating.

One professional ocarina instructor and 3 trained assistants ran the group program twice a week for 1 h each session. Except for the first week of breathing training, all sessions consisted of 20 min of breathing training and 40 min of playing the instrument.

In Y community center with the 10-week program ("10WPG"), 7 participants dropped out or did not attend the posttest due to other leisure activities, outpatient treatment, child rearing, headache, or work, and in D community center with the 5-week program ("5WPG"), 4 participants dropped out and did not attend the posttest due to hospital admission and other leisure activities. Ultimately, 13 participants in the 10-week program and 16 participants in the 5-week program attended the posttest and their data were collected.

Outcome measurements

Pulmonary function test (PFT)

A portable spirometer (CHESTGRAPH HI-101, CHEST M.I. INC., Japan) was used to test lung functions of the participants. In order to make an accurate measurement and to prevent any infections, the participants used a nose clip and held the lung function test filter in their mouths in a seated position (Figure 1). After a maximum inhalation, the exhalation with the most effort was set as forced vital capacity (FVC), and the forceful exhalation for 1 s after a maximum inhalation was set as forced expiratory volume in 1 s (FEV1). Through these settings, FEV1/FEV ratio (FEV1%) was calculated and the amount of breathing as fast as possible for 15 s was converted to a value for 1 min as maximum voluntary ventilation (MVV). A physical therapist with experience in lung function tests measured twice each time and used the greater value for data analysis, and enough resting time was given in between tests.

6-minute walk test (6MWT)

The 6MWT was conducted to measure cardiopulmonary endurance of the participants. The distance the participants walked quickly in a square 25-meter track for 6 min was recorded in meters. A standardized method was used for measurement by 1 assessor. The assessor encouraged the participants to walk

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Table 1. General characteristics of the participants.

Variables	10WPG (n=13)	5WPG (n=16)	t	p
Age (years)	69.25±2.41*	70.94±2.38	−1.86	0.072
Height (cm)	155.33±2.53	155.29±5.87	0.22	0.983
Weight (kg)	56.25±6.82	57.01±8.29	−0.273	0.787
BMI (kg/m²)	23.31±2.79	23.58±2.69	−0.263	0.795
MMSE-K (scores)	27.66±1.37	28.00±1.76	−0.571	0.573

* Mean ± standard deviation. 10WPG – 10 weeks program group; 5WPG – 5 weeks program group; BMI – body mass index; MMSE-K – mini mental state examination-Korea version.

with their greatest effort and notified the participants how much time has passed every minute. 6MWT has a high inter-rater reliability of r=.91 [13].

Breathing discomfort

The degree of breathing discomfort felt by the participants after the 6MWT was measured with the modified Borg scale (MBS). The subjective degree of discomfort was selected from a picture between 0 and 10 and a number from a 12-point scale. 0 means "does not feel any breathlessness" and 10 means "feels extremely breathlessness". The MBS shows a high correlation after the lung function test and 6MWT [14].

Life satisfaction scale (LSS)

The measurement of quality of life of elderly women participants used a LSS for the elderly that has been modified to Korean conditions from the research of Kozma and Stones [15]. This tool measures the level of life satisfaction of the elderly. It consists of 4 items each for positive and negative emotions and 6 items each for positive and negative everyday experiences, with a total of 20 items. Each item has a 3-point scale, where 3 means "Agree", 2 means "Somewhat Agree", and 1 means "Disagree". The range of total score is 20–60, where the score closer to 60 shows higher life satisfaction. The Cronbach's alpha was α=.85. All participants went through the pretest 1 day before the intervention program and went through the same process for posttest on the day after the termination of the program. All measurements were performed in a standardized method by a trained assessor.

Statistical analysis

The collected data were analyzed using SPSS Win ver. 19.0. General characteristics of the participants are given in mean and standard deviation values after descriptive statistics, and the Shapiro-Wilk test was used to assess normality. Homogeneity of general characteristics of the participants and prior measurement values were analyzed through the independent-samples *t* test. We used the paired *t* test for before and after comparison of within-group intervention effects and we used the independent-samples *t* test to compare the difference in values of groups by intervention duration. Repeated measures analysis of variance was used to identify the change over time and the effects of interaction between time and groups. Statistical significance was set to α<.05.

Results

General characteristics of the age, height, weight, body mass index (BMI), and MMSE-K scores of the participants in each group were all of equal quality (Table 1). The values of pre-intervention FVC, FEV1, FEV1%, and MVV through the lung function test showed homogeneity for both groups. The change of FVC values before and after the intervention depending on the intervention period showed significant improvement in both groups (p<.05), but there was no significant difference between the groups depending on the intervention period. The changes in before and after intervention FEV1 values depending on the intervention period showed significant improvement for both groups (p<.05), and there was also a significant difference between the groups depending on the intervention period (p<.05). There was no significant difference in before and after intervention FEV1% values depending on the intervention period, and there was no significant difference between the groups depending on the intervention period. Before and after intervention MVV values depending on the intervention period showed a significant improvement in the 10WPG (p<.05), and a significant difference between the groups depending on the intervention (p<.05) (Table 2).

The values of pre-intervention 6MWT showed homogeneity for both groups. Before and after intervention changes depending on the intervention period showed significant improvements for both groups (p<.05), and there was a significant difference between the groups depending on the intervention period (p<.05) (Table 3).

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Table 2. Comparison of cardiopulmonary function within groups and between groups.

Variables		10WPG (n=13)	5WPG (n=16)	t(p)	Time F(p)	Time×group F(p)
FVC(ℓ)	Pre	2.31±0.32*	2.21±0.35	.745 (.462)	13.968 (0.001)	0.072 (.790)
	Post	2.43±0.24	2.31±0.31			
	Post-pre	0.11±0.16	0.09±0.15	.269 (.790)		
	t(p)	−2.486 (.030)	−2.801 (0.013)			
FEV1(ℓ)	Pre	1.80±0.29	1.71±0.29	0.881 (0.386)	27.746 (0.000)	4.426 (0.045)
	Post	1.91±0.25	1.75±0.26			
	Post-pre	0.11±0.09	0.04±0.06	2.104 (0.045)		
	t(p)	−3.780 (0.003)	−3.056 (0.008)			
FEV1%	Pre	78.77±12.96	77.08±6.83	0.456 (0.652)	0.298 (0.590)	0.555 (0.463)
	Post	79.00±10.08	75.57±4.55			
	Post-pre	0.23±8.03	−1.52±4.66	0.745 (0.463)		
	t(p)	−0.101 (0.921)	1.346 (0.197)			
MVV (ℓ/min)	Pre	60.79±13.78	60.58±14.30	.039 (.969)	20.478 (0.000)	4.278 (0.048)
	Post	67.22±12.47	62.97±14.01			
	Post-pre	6.42±3.97	2.40±5.85	2.608 (.048)		
	t(p)	−5.606 (0.000)	−1.687 (0.111)			

* Mean ± standard deviation. 10WPG – 10 weeks program group; 5WPG – 5 weeks program group; FVC – forced vital capacity; FEV1 – forced expiratory volume in 1 second; FEV1% – FEV1/FEV ratio; MVV – maximum voluntary ventilation.

Table 3. Comparison of cardiopulmonary endurance and quality of life within groups and between groups.

Variables		10WPG (n=13)	5WPG (n=16)	t(p)	Time F(p)	Time×group F(p)
6MWT (m)	Pre	545.58±117.65*	549.00±72.42	−0.097 (0.924)	19.362 (0.000)	5.025 (0.033)
	Post	646.58±49.96	581.82±67.14			
	Post-pre	101.00±116.38	32.83±40.84	2.242 (.033)		
	t(p)	−3.006 (0.012)	−3.314 (0.004)			
MBS (score)	Pre	4.66±0.98	4.59±0.94	0.217 (0.830)	12.580 (0.001)	7.125 (0.013)
	Post	3.42±0.67	4.41±0.87			
	Post-pre	−1.25±1.29	−0.17±0.88	2.669 (.013)		
	t(p)	3.362 (0.006)	1.376 (0.188)			
LSS (score)	Pre	29.08±5.93	28.70±5.21	.182 (.857)	7.973 (0.009)	4.285 (0.048)
	Post	33.67±5.79	29.41±5.57			
	Post-pre	4.58±2.71	0.71±6.05	2.070 (.048)		
	t(p)	−5.854 (0.000)	−0.481 (0.637)			

* Mean ± standard deviation. 10WPG – 10 weeks program group; 5WPG – 5 weeks program group; 6MWT – 6 minute walk test; MBS – modified Borg scale; LSS – life satisfaction scale.

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The values of pre-intervention MBS that measured breathing discomfort degree showed homogeneity for both groups. Before and after intervention changes depending on the intervention period showed significant improvements for 10WPG ($p<.05$), and there was a significant difference between the groups depending on the intervention period ($p<.05$) (Table 3).

The values of pre-intervention LSS that measured quality of life showed homogeneity for both groups. Before and after intervention changes for LSS depending on the intervention period showed significant improvements for 10WPG ($p<.05$), and there was a significant difference between the groups depending on the intervention period ($p<.05$) (Table 3).

Discussion

Prior research reported through discussion that respiration training not only enhances motor function of patients with respiratory diseases and shortens their hospital stay, but also affects the improvement in quality of life [16]. Most of the intervention programs (more than 65%) are hospital-centered interventions for patients with respiratory diseases or a hybrid intervention provided in both the hospital and at home [17]. Although it is crucial to demonstrate the effects of respiratory rehabilitation program for patients, it is equally important to prove the effects of the program for people who are vulnerable to respiratory diseases in the community. Research is needed for continuous accumulation of scientific evidence for respiratory disease prevention, decrease of symptoms, enhancement of physical, social, and psychological functional status, promotion of quality of life, decreased hospital admission rate, and lowered medical fees [18].

This study investigated the differences in effects of respiratory training programs for elderly women, depending on the duration, using wind instruments. The results confirmed that longer participation in the program yielded positive effects in lung functions, cardiopulmonary endurance, and quality of life. The FVC value that was examined through lung function test and showed that 10WPG and 5WPG had increases of 5.19% and 4.25%, respectively. FEV1 had 6.11% and 2.34% increase in 10WPG and 5WPG, respectively, and 10.58% and 3.95% increase for MVV. This conforms to the study by Jeong [12] showing that respiratory training using wind instruments increased FEV1 of the elderly by 3.3%, and it also agrees with the study by Jang [11] in which respiratory training that used a recorder increased FEV1% by 2.8% in asthma patients. In order to play wind instruments, lips must be pursed on the mouthpiece and air must be blown slowly. This motion naturally induces pursed-lip breathing. This exhalation pattern forms positive pressure of the airway and increases the elasticity of the respiratory tract and alveoli, resulting in FEV increase. In addition, if diaphragm breathing is done simultaneously, the abdominal pressure increases as the amount of air intake increases. This enhances the effectiveness of ventilation and supports respiratory circulation. Gomieiro et al. [19] reported that their 16-week respiratory program that consisted of pursed-lip breathing and diaphragm breathing increased lung function of asthma patients (increases in maximum inhaling pressure by 27.6% and maximum exhaling pressure by 20.54%) and strengthened respiratory muscles. With these results, FVC, FEV1, and MVV is considered to show significant increases due to pressure increase during respiration of the participants through repetitive practice of respiration patterns in the 10-week wind instrument program.

Respiratory disease is a systemic problem, in which factors of motor function, respiratory distress, and quality of life, along with respiratory function, must be evaluated [20]. The most appropriate index for assessing motor performance ability is the measurement of maximum oxygen consumption through the exercise stress test, but a functional motor performance ability index of 6MWT is more appropriate because elderly people at high risk for cardiovascular diseases or patients with respiratory disease cannot not perform exercise at maximum stress and easily feel respiratory distress with simple activities of daily living [21]. 6MWT has a high correlation with the performance of activities of daily living and subjective respiratory distress degree; thus, it is used as an index for respiratory distress after walking tests [18,22]. Guell et al. [23] reported a significant increase in walking distance and a significant decrease in respiratory distress after 6MWT through chest physical therapy and respiratory training in patients with chronic obstructive lung disease (COPD). Ries et al. [24] reported a significant difference in 6MWT scores between groups for exercise tolerance of COPD patients after a 12-month respiratory program. Lee [25] studied COPD patients by applying muscle strengthening and respiratory training 4 weeks during hospital admission and 4 weeks after discharge, and reported a 47% (99 m) increase in 6 min walking distance and 12.5% decrease in respiratory distress. This research with elderly women with normal respiratory functions resulted in 18% (101m) and 6% (32.83m) each for 10WPG and 5WPG, respectively, and showed a decrease in respiratory distress of 26% and 4%, respectively. Solway et al. [26] suggested that the change in distance in 6MWT must be more than 54 m to be clinically significant, and Oh [17] reported that a complex respiratory exercise program is more effective in general health promotion than simple exercise education or respiratory training. Compared to the results of these prior studies, long-term respiratory training using wind instruments produces greater improvements in motor functions and decreases in respiratory distress.

Evaluation of quality of life in patients with respiratory diseases is essential to assess intervention effects along with

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assessments of respiratory and motor functions [27]. The Chronic Respiratory Disease Questionnaire (CRDQ) is typically used to assess quality of life through physical and emotional changes that result from respiratory training interventions that improve respiratory distress and easier performance of activities of daily living and leisure activities [28]. Considering that the participants in this study were elderly women with no respiratory diseases, the results of CRQD may have shown a bottom effect. Therefore, this study assessed life satisfaction degree as the index for quality of life, and satisfaction in 10WPG was increased by 15.78% and 2.47% in the 5WPG. Regular exercises and participation in leisure and social activities have close relationship with enhanced life satisfaction in the elderly. Additionally, approaches and interventions based on symptom clusters have greater effect on quality of life than programs customized to a single individual [29]. Having these prior studies as the background, the participants who participated in a respiratory program with their peers encouraged each other to persist in participation, and the process of learning a new instrument gave them a sense of accomplishment and an opportunity to let others know about their abilities.

This study has some limitations that may have affected the validity of the study. First, the participants were not grouped randomly, and homogeneity data for pretest measurement values and general properties of the 2 groups were not collected. However, homogeneity data were collected after excluding the data of the participants who dropped out to analyze with appropriate statistical methods. Second, elderly women from 2 different community centers were not able to control participation in additional programs. Some participants participated in other programs additionally within the center, such as yoga, dance, and singing, and the effects of these programs on the results of the study were not considered. Third, life satisfaction level depending on factors such as income level and education level were not considered. It is speculated that satisfaction with program participation and quality of life may differ by income and education levels. Fourth, the comparison was made only on the 2 groups by before and after interventions, but long-term effects of the program were not evaluated. Future studies require randomization of the participants, control over the activities that may affect the results, and assessing the long-term effects of more complex programs.

Conclusions

This study a provided wind instrument program with respiratory training to elderly women who may be vulnerable to respiratory diseases. As a result, elderly women who participated in the 10-week program showed improvements in respiratory function, motor function, and quality of life. This study result suggests the implementation of the programs in various community centers, and additional programs may support more studies to prevent respiratory diseases in elderly women and general health promotion.

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