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Effects of Vibration Foam Roller Stimulation and Thoracic Stabilization Exercise for 6 Weeks on Upper Limb Strength and Respiratory Function in the Elderly

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Abstract

Background/Objectives: To investigate the effects of vibration foam roller stimulation and thoracic stabilization exercises (TSE) on upper limb strength and respiratory function in the elderly.

Methods/Statistical analysis: Thirty-one elderly people over 60 years of age were allocated to VFRSE (vibration foam roll with stabilization exercise, n=16) and SE (stabilization exercise, n=15) and tested. Intervention of the VFRSE group involved 15 minutes of vibration foam roller exercises and 15 minutes of TSE three times a week, while that of the SE group involved 30 minutes of TSE three times a week. All subjects underwent baseline evaluations and re-evaluations before and after the 6-week intervention.

Findings: After the 6-week intervention, statistically significant increases in hand grip strength, FVC, and FEV1 were observed in the VFRSE group ($P<0.05$). In the SE group, only hand grip strength increased significantly ($P<0.05$). Statistically significant differences were demonstrated in FVC and FEV1 between the VFRSE and SE groups ($P<0.05$), but no significant in hand grip strength ($P>0.05$).

Improvements/Applications: Vibration foam roller stimulation with thoracic stabilization exercises influence upper limb strength and respiratory function. Thus, we suggest the application of these intervention on the elderly with decreased upper limb strength and respiratory function.

Keywords**:** Vibration foam roller, Thoracic stabilization exercise, Upper limb strength, Respiratory function, Elderly

1. Introduction

As aging occurs, bronchial obstruction occurs even without chronic obstructive pulmonary disease and the maximum inhalation and exhalation pressure, which indicates the function of the respiratory muscles, and the forced vital capacity and maximum minute ventilation decrease[1]. These findings suggest that the prevalence of pulmonary diseases and the decrease in function due to aging may be correlated[2]. Decreased lung function is greatly affected by age[1-3].

Movement of the thoracic cage, which is related to the breathing ability, is controlled not only by the movement of the spine and ribs, but also by the coordinated movements of various nearby joints[4]. Disease conditions may decrease the coordinated movements and control of these joints. Therefore, an exercise to improve the overall movements of the skeletal system and mobility of the thoracic cage is necessary[5].

Vibration is effective in increasing muscle contraction and can be used to control pain or enhance the effects of exercise[6]. Vibratory stimulation accelerates muscle contraction and relaxation, which leads to increased muscle fiber recruitment with a low risk of tissue damage. Moreover, mechanical effects of vibration include circulation enhancement, stretching, adhesion prevention, increased flexibility, and reduced pain[7]. Vibratory stimulation can also temporarily increase the levels of certain hormones such as growth hormones and induce muscle spindles activity, which affect the muscles of both the stimulated and adjacent regions[8,9]. It has been recommended to apply vibration to the body at 30 Hz and an amplitude of 2.5 mm; however, the optimal whole-body vibration frequency and amplitude are not clearly outlined[10].

Spinal stabilization exercise provides sensory feedback and stimulation for the integrity of the spine to maintain normal function and strengthen the engram. This leads to posture adjustment without conscious control in daily life movements and habitual postures[11]. Thoracic stabilization exercises promote active stabilization and sensation by contractile tissues, thus strengthening neuromuscular control. The purpose of these exercises is to restore muscle and movement control[12,13].

In order to prevent the degeneration of respiratory function caused by aging, strengthening of the diaphragm and respiratory muscles is important. Furthermore, studies on the mobility and stability of the spine are fundamental. Therefore, this research aimed to investigate effects of vibration foam roller stimulation and thoracic stabilization exercises on upper limb strength and respiratory function in the elderly.

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2. Materials and Methods

2.1. *Participants*

This research was conducted on 36 elderly participants who visited public health center A located in S City, Gyeonggi-do. The number of subjects required for this study was calculated using Cohen's formula by the G*Power program. To maintain the power of analyses performed before and after the 6-week exercise intervention, the effect size and significance level were set to 0.25 and 0.05, respectively. The power value was set to 0.8, and the number of measurements was set to 3 to calculate the sample size. Minimum total sample size required for this research was 28. By considering a dropout rate of 10~20%, a total of 36 subjects, with 18 subjects for each of the two groups, were recruited for the study.

2.2. *Randomization*

The selection criteria for this research were: 1) 60 years old or older, 2) those who did not have orthopedic problems such as lower extremity fractures within the last 6 months, 3) those who had obstructive lung diseases (forced expiratory volume in 1 second/forced vital capacity [FEV1/FVC]≥ 65%, FVC<80%) when measuring FEV1/FVC and those without a history of heart or lung diseases, and 4) those who had the cognitive ability to fully understand how to measure lung function and muscle strength[14]. Information including general characteristics of the subjects was collected after receiving informed consent at the time of recruitment. Afterward, the purpose of the study and the exercise to be performed were explained to the eligible subjects and their guardians. The participants were then randomly allocated to either the vibration foam roller with stabilization exercise (VFRSE) group or the stabilization exercise (SE) group using Research Randomizer (http://www.randomizer.org/), with 18 participants in each group. Due to personal reasons, two and three subjects from the VFRSE and SE groups, respectively, dropped out in the middle of the study period. Intervention of the VFRSE group involved 15 minutes of vibration foam roller exercises and 15 minutes of thoracic stabilization exercises (TSE) 3 times a week, while that of the SE group involved 30 minutes of TSE three times a week. All subjects underwent baseline evaluations and re-evaluations before and after the 6-week intervention.

2.3. *Intervention*

2.3.1. Vibration foam roller exercises

The foam roller exercise program was conducted using a vibration foam roller (TRATAC, Naumcare, Korea) of the same material. The vibration mode of this product consists of four levels, with levels 1 and 2 being the low-intensity vibration mode with 1300 and 2000 RPM, respectively; level 3 being the rhythm pattern mode with 2,800~3,200 RPM; and level 4 being the power mode with 3700 RPM. In this study, levels 1 and 2 were used according to the comfort and pain levels of the subjects. The exercises were performed in three sets for 15 minutes in total, with each set consisting of 5 minutes of exercise and 1 minute of break. Participants were asked to supine position on a bed with an adjustable tilt, and 40~60° inclination was applied to the upper body. A therapist with 10 years of experience in physical therapy performed the vibrational foam roller stimulation and posture adjustments on the subjects.

2.3.2. Thoracic stabilization exercise

The thoracic stabilization exercise regime was designed based on McKenzie's extension exercise and previous studies and consisted of a total of four exercises[16], including warm-up, main, and cool-down exercises in table 1. The SE group performed a 30-minute exercise program, while the VFRSE group performed the spine stabilization program involving warm-up (3 minutes), main exercise (5 sets, 10 minutes), and cool down (2 minutes).

Table 1: Thoracic stabilization exercise program of the SE group

	Exercise	Contents	Repetition	Duration
Warm-up	Stretching	• The shoulders are pulled backward and downward, while the head and chin are pulled inward to balance the head. • The right hand is placed on left side of the crown, and chin is pulled inward to bend the neck, so that the nose touches the left armpit. With minimal movement of the neck, the upper body is tilted rightward and forward, so that the left posterior part of neck is stretched.		5 min

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<table>
<tr><td rowspan="2">Main exercise</td><td>Back rotation exercise in the side-lying position</td><td>• While the left elbow is straight, a 1 kg heavy dumbbell is held vertically. The subject has to lie down on the right side with the head on the roller.
• The right leg is kept straight and tilted back slightly to keep the back tilted. The left hip and knee joints are to be bent, and the left foot is placed on the right knee.
• After inhaling, the head is turned while exhaling slowly with the mouth, and the back is slowly turned to the left.
• Hold for 10 seconds. After returning to the starting position, rest for 5 seconds, and repeat the exercise on the opposite side.</td><td rowspan="2">10 sets</td><td rowspan="2">20 min</td></tr>
<tr><td>Seated back tilt exercise</td><td>• The hands are locked and placed on the back of the head.
• The chin is pulled back. Inhale and exhale slowly while raising the chest and arms without tiling the neck backward.
• Maintain this position for 10 seconds and return to the starting position.</td></tr>
<tr><td>Cool-down</td><td>Walking</td><td>Treadmill: 1.0-3.0 km/h</td><td></td><td>5 min</td></tr>
</table>

2.4. *Outcome measures*

2.4.1. Respiratory function

Fitmate MED (Cosmed, Italy), which can measure the lung capacity and maximum inhalation and exhalation pressure, was used as the measuring tool in this study. Prior to the measurement of FEV1 and FVC, the subjects underwent three repetitive practice sessions along with training to ensure accurate measurements. The average value of the three repeated measurements was recorded.

2.4.2. Upper limb strength

The grip strength test was performed to measure upper limb strength[17]. The subjects were asked to hold the grip dynamometer (TKK-5401, TAKEI, Japan) with the proximal interphalangeal joints perpendicular to the gripping part of the dynamometer. Measurements were recorded in the standing position, with both arms slightly wide apart and the grip dynamometer not touching the body. The left and right sides were each measured three times, and the average was recorded.

2.5. *Data analysis*

Data analysis was conducted using IBM SPSS 22.0. The Kolmogorov–Smirnov was performed to determine whether variables were normally distributed. The paired t-test was used to compare the muscle strength and respiratory function before and after each group experiment. The independent t-test was used to compare the homogeneity and amount of change between groups. The statistical significance level (α) was set to 0.05.

3. Results and Discussion

3.1. *General characteristics of subjects*

There are no significant differences in sex, age, height, and weight were observed in the VFRSE and SE homogeneity tests, as shown in Table 2

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Table 2: General characteristics of subjects

(Mean ± SD)

General characteristic		VFRSE (n = 16)	SE (n = 15)	p
Sex	Male	9	9	0.32
	Female	7	6	
Age (year)		72.32 ± 5.95	71.27 ± 6.09	0.19
Height (cm)		163.02 ± 6.96	163.17 ± 5.37	0.52
Weight (kg)		62.31 ± 10.18	63.25 ± 7.10	0.89

VFRSE: vibration foam roller with stabilization exercise group, SE: stabilization exercise group

3.2. *Comparison of hand grip strength and respiratory function*

After the 6-week intervention, statistically significant were observed for hand grip strength, FVC, and FEV1 in the VFRSE group. In the SE group, only hand grip strength increased significantly in Table 3.

Physical activity often decreases in the elderly, resulting in loss of muscle mass. This decrease in muscle mass during aging negatively affects muscle strength, daily life, functional ability, and independence[18].

In this study, it is believed that the significant increase in hand grip strength in both the VFRSE and SE groups was caused by vibratory stimulation of the spine. This leads to continuous passive stimulation of the muscles, joint capsules, and joint ligaments, causing mechanical changes in the joints and soft tissues and restoring the mobility of the spine. Therefore, improvement in joint movement is induced and the torso is stabilized, which leads to increased hang grip strength[19,20]. Qelenay et al. reported that an 8-week TES program improved core weakness and balance disorders[21]. Based on previous studies, we postulated that the spine stabilization exercises increased core strength, which consequently improved hand grip strength.

Spine vibration stimulation decreases joint stiffness and increases joint mobility. This results in increased movement of the chest wall and, thus, improves the overall respiratory function[22]. Moreover, it is thought that spine stability exercises are effective in improving the respiratory function of the elderly. These exercises facilitate breathing and trunk flexion and are involved in posture and body function, leading to the increased participation rate of respiratory muscles, which would normally be reduced due to stooped posture[22,23].

Table 3: Comparison of hand grip strength and respiratory function pre- and post-intervention

(Mean ± SD)

		VFRSE (n = 16)			SE (n = 15)			Change between groups (p)
		Pre-test	Post-test	p	Pre-test	Post-test	p	
Hand grip strength		21.24 ± 2.21	23.02 ± 2.69	0.03*	21.75 ± 4.08	22.82 ± 3.14	0.04*	0.08
Respiratory Function	FVC	1.27 ± 0.36	1.41 ± 0.87	0.01*	1.30 ± 0.34	1.35 ± 0.63	0.10	0.01*
	FEV1	1.32 ± 0.58	1.51 ± 0.65	0.03*	1.29 ± 0.41	1.20 ± 0.33	0.12	0.04*

*$p < 0.05$, FVC: Forced vital capacity, FEV1: Forced expiratory volume in 1 second, VFRSE: vibration foam roller with stabilization exercise group, SE: stabilization exercise group

Statistically significant differences were demonstrated in FVC and FEV1 between the VFRSE and SE groups, but not in hand grip strength in Table 3.

Vibration can induce an increase in muscle strength by sensitizing the muscular axis and stimulating the joints and adjacent muscles, thus increasing proprioceptive sensibility, activating the muscles and nerves, and facilitating blood circulation[8,24].

Breathing is also affected by the strength of the respiratory muscles. Aging causes changes in the structure of the spine and muscles[25]. As age increases, the mass of respiratory muscles decreases, and such weakening of the muscles is known to cause a decrease in respiratory function[26]. Thoracic movements are closely related to breathing ability and are achieved through the cooperative control of various joints in the trunk[26].

In this study, it is thought that the electric foam roller stimulation influenced the respiratory muscles by stimulating the spine joints and nerves, thereby increasing respiratory function [8,24, 28-31]. In addition, positive physiological changes such as increased blood circulation and reduced fatigue substances and stress through spine stabilization exercises improved the respiratory function of the VFRSE group[21,27].

This study was conducted on healthy elderly subjects from local communities. Therefore, the results cannot be generalized to all elderly individuals, and the insufficient sample size was a limitation of this study. Therefore, based on this study, continuous studies on joint movement and exercise interventions conducted for various respiratory disorders in different age groups are warranted.

4. Conclusion

This study compared the effects of vibration foam roller stimulation and thoracic stabilization exercises on upper limb strength and respiratory function in a total of 31 adults over the age of 60 years. After the 6-week intervention, statistically significant increases in hand grip strength, FVC, and FEV1 were observed in the VFRSE group, while only hand grip strength increased significantly in the SE group. The intergroup comparison showed that significant differences in FVC and FEV1 were observed between the VFRSE and SE groups.

Vibration foam roller stimulation with thoracic stabilization exercises influence upper limb strength and respiratory function. Thus, we suggest the application of these intervention on the elderly with decreased upper limb strength and respiratory function. Furthermore, we believe that these exercises may be used for disease prevention in healthy elderly individuals.

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