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Effect of thoracic cage mobilization on respiratory function, spinal curve and spinal movement in patients with restrictive lung disease

This study aimed to examine the effects of thoracic cage mobilization on the respiratory function, spinal curve and spinal movement in patients with restrictive lung diseases. The subjects were ten community-dwelling elderly with a restrictive lung diseases when measured using a spirometer(FEV1/FVC≤65%, FVC<80%). They received an intervention over an eight-week period: three times a week and for 30 minutes a day. SPSS for Windows(ver. 19.0) was used to analyze all the collected data. Independent t-tests were used to examine changes before and after the intervention. The study's results showed statistically significant improvement(p<.05) in forced expiratory volume in 1 second(chage rate: .24±.25), thoracic curve(chage rate: -2.50±2.76), lumbar curve(chage rate: -.80±1.32), thoracic flexion(chage rate: 2.10±1.52), thoracic extension(chage rate: -2.00±1.25), lumbar flexion(chage rate: 2.40±3.13) and lumbar extension(chage rate: -1.30±1.42). The results of this study suggest that the thoracic cage mobilization contribute to improve pulmonary function in patients with restrictive lung disease.

Key words: *Respiratory Function, Restrictive Lung Disease, Spinal Curve, Spinal Movement, Thoracic Cage Mobilization*

Joong San Wang

Howon University, Gunsan; Korea

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Address for correspondence
Joong San Wang, PT, Ph.D
Department of Physical Therapy, Howon University, 64, Howondae 3-gil, Impi-myeon, Gunsan-si, Jeollabuk-do, Korea
Tel: 82-10-8945-3520
E-mail: king9655@empas.com

INTRODUCTION

Restrictive lung diseases are a type of respiratory system disease caused by several factors, such as respiration-related anatomical structures and the nerve root mechanism(1). The elderly generally experience reduction in forced vital capacity(FVC), forced expiratory volume in 1 second(FEV1), and FEV1/FVC(2,3). Restrictive lung diseases are diagnosed when the FEV1/FVC is 65% or less and the FVC is 80% or less(4). One of the characteristics of restrictive lung diseases is difficult breathing(1). In the respiration-related systems, chest alignment and movements in the chest wall are significantly associated with respiratory function(5), while slouching posture, resulting from aging(6), and reduction in spinal movement(7) play negative roles in respiration in the elderly.

Slouching posture that develops with aging, along with restrictive lung diseases, may begin a vicious circle of negative factors affecting general body functions, such as respiratory function, spinal curve, and spinal movement, thus requiring specified pulmonary physical therapies for improvement.

Current pulmonary physical therapies provide various intervention methods, using many breathing devices and breathing exercises(8,9), but few studies have demonstrated such methods applied to respiratory function and body alignment of the elderly. Recently, research has reported changes in respiratory function when joint mobilization in manual therapy was applied(10,11). Although joint mobilization of the thoracic vertebrae has been reported to be an effective intervention in improving chronic neck pain, chronic backache, respiratory function, and spinal movement(10,12), there have been few studies performed on the elderly or respiratory failure.

In this study, we investigated the effects of thoracic cage mobilization, performed on the elderly with restrictive lung diseases, on improvement in respiratory function, spinal curve, and spinal movement, presenting an intervention method of pulmonary physical therapy that can be used clinically.

METHODS

Subjects

The subjects of this study were ten people, aged at least 60 years, who lived in Gyeonggi-do, South Korea between January and November 2014 and had restrictive lung diseases(4) based on an FEV1/FVC of $\leq$65% and FVC of $<$80% revealed during preliminary investigation with respiratory measurement devices. The subjects each earned at least 24 points on the Korean version of the Mini-Mental State Exam (MMSE-K)(13) and were able to walk independently. We explained the purpose of this study, and the subjects consented to their participation. Those with central nervous system surgical history or history of surgery in the vestibular system or spine, as well as those who had been treated for respiratory diseases at the time of the investigation, were excluded from this study.

Of the ten subjects, two were male(20.0%) and eight were female(80.0%). All were at least 60 years old(63.33±4.37), 160.17±6.88cm in height, and 60.33±5.39kg in weight.

Measurement Methods

Respiratory function

We measured the FVC, FEV1, and FEV1/FVC of the subjects using a Fitmate MED(Cosmed, Italy). For accuracy in respiration measurement, we repeatedly educated the subjects on the test methods three times. During measurement, each subject was asked to face front, in a sitting position, while wearing a nose clip, and an investigator encouraged the subject to display his/her maximal respiratory capacity.

Spinal curve and spinal movement

We used a spinal mouse(Idag, Swiss) to measure the spinal curve and the spinal movement of the subjects. The device showed superior reliability with correlation coefficients of r=.90 for flexion and r=0.85 for extension, intra-class coefficients of r=0.95 for flexion, and r=0.92 for extension(14). While a subject stood in his/her usual comfortable posture, an investigator placed skin markers on the spinous process of the seventh vertebra and on the third sacrum and dragged down the spinal mouse between the two markers to measure the spinal curve(15). To measure spinal movement, an investigator dragged down the mouse between the markers while the subject actively bent and straightened his/her back(15).

Intervention Methods

For intervention, we applied joint mobilization to the thoracic cage. This was performed for 30 minutes per day, three times per week, for eight weeks. The joint mobilization consisted of thoracic segmental mobilization(extension) accompanied by spinal traction and specific rib mobilization(ventral)(16).

The mobilization was applied for 25 to 30 seconds, while the subject was in the sitting position, during which he/she did not feel discomfort based on the grade III(17). Mobilization sessions lasted a total of 30 minutes, including three-second rests between each session(12,18).

Data analysis

All data collected in this study was analyzed using SPSS Statistics for Windows (version 19.0). Descriptive statistics were used to understand general characteristics of the subject. Independent t-test was used to identify changes in respiratory function, spinal curve, and spinal movement of the subjects. The level of statistical significance for all analyses was set at α=.05.

RESULTS

Change of respiratory function

In an analysis of the effects of thoracic cage mobilization on respiratory function, all FVC, FEV1, and FEV1/FVC increased. In particular, the FEV1 increased from 1.47±.27 pre-intervention to 1.71±.30 post-intervention, showing significant improved changes($p<.05$)〈Table 2〉.

Change of spinal curve

In an analysis of the effects of thoracic cage mobilization on the spinal curve, both thoracic curve and lumbar curve showed improvement. In particular, the thoracic curve was reduced from 48.50±3.41° pre-intervention to 46.00±4.97° post-intervention, showing significant improvement in back posture($p<.05$)<Table 3>.

Change of spinal movement

In an analysis of the effects of thoracic cage mobilization on spinal movement, thoracic flexion and thoracic extension($p<.01$), as well as lumbar flexion and lumbar extension($p<.05$), showed significant increases<Table 3>.

DISCUSSION

This study was performed to investigate the effects of thoracic cage mobilization on improving the respiratory function, spinal curve, and spinal movement of the elderly with restrictive lung diseases. When thoracic cage mobilization was applied, patients' FVC, FEV1, and FEV1/FVC increased, and the FEV1 was significantly improved($p<.05$).

Normal respiratory activity requires the movement of several joints within the thoracic cage(19). Respiration volume can increase when the ribs expand the thoracic cage through bucket handle movement and pump handle movement (20).

However, when the joints of the thoracic cage gain stiffness due to aging(19), the joint movements in respiration are restricted. The thoracic cage mobilization in this study might reduce the stiffness of the respiration-associated joints to increase rib movement and to expand the thoracic cage, inducing improvement in the respiratory function of the elderly with restrictive lung diseases.

Several research reports detail changes in respiratory function when mobilization is applied to the spinal column. McGuiness et al.(21) reported that posterior-anterior mobilization, applied to the cervical vertebrae, increased respiratory rate by 44%. It also increased diastolic blood pressure, systolic blood pressure, and heart rate. The results of Kingston et al.(11), which reported that spinal mobilization affected respiratory rate and the sympathetic nervous system, may be consistent with those of this study.

In this study, we measured the thoracic and lumbar curves of the elderly with restrictive lung diseases when they were in their usual, relaxed

Table 1. Change of respiratory function

Variable	Pre	Post	change	t	p
FVC(ℓ)	1.92±.20	2.06±.28	.14±.21	2.035	.072
FEV1(ℓ)	1.47±.27	1.71±.30	.24±.25	3.017	.015*
FEV1/FVC(%)	74.00±9.75	75.20±12.73	1.20±15.32	.248	.810

Mean±SD, *p<.05
FVC: forced vital capaity, FEV1: forced expiratory volume at 1 second

Table 2. Change of spinal curve and spinal movement

Variable	Pre	Post	change	t	p
Thoracic curve(°)	48.50±3.41	46.00±4.97	−2.50±2.76	−2.866	.019*
Lumbar curve(°)	−16.50±4.62	−17.30±4.42	−.80±1.32	−1.922	.087
Thoracic flexion(°)	9.30±4.52	11.40±5.36	2.10±1.52	4.358	.002**
Thoracic extension(°)	−7.50±3.31	−9.50±3.60	−2.00±1.25	5.071	.001**
Lumbar flexion(°)	38.90±4.18	41.30±4.64	2.40±3.13	2.422	.039*
Lumbar extension(°)	−5.10±1.97	−6.40±1.35	−1.30±1.42	−2.899	.018*

Mean±SD, *p<.05, **p<.01

standing posture, analyzing their spinal movements via trunk flexion and extension. The normal thoracic curve is generally around 40°, but the angle increases with age(19). The thoracic curve of the subjects was 48.50±3.41° before the intervention, a result that was consistent with those of other studies(6) which reported increased thoracic curve with aging, causing a slouching posture. After the thoracic cage mobilization was applied, the curve was reduced to 46.00±4.97°, indicating that the back postures were significantly improved($p<.05$). According to Bautmans et al.(22), older females with thoracic kyphosis and osteoporosis displayed significant reduction in the thoracic curve, from 52.5±2.2° to 49.1±2.0°, as well as consequent postural improvement after exercise intervention, including spinal mobilization, a result that was similar to those of this study. Although just a few studies have reported that mobilization was effective on postural improvement in the elderly with slouching posture, this study may prove the method to be an effective physical therapy. As for changes in spinal movement, the subjects of this study showed significant increases in both thoracic flexion and thoracic extension($p<.01$) as well as lumbar flexion and lumbar extension($p<.05$), indicating improvement in the movement both in the back and the waist. The results of this study are consistent with those of other studies(10,12) in which mobilization applied to the spines of patients with chronic lumbar pain or cervical pain improved their spinal movement. The results also demonstrate that even the elderly whose average age was higher than those in other studies showed improvement in their spinal movement through the intervention.

An interesting topic for further study could combine mobilization with pulmonary physical therapy for stroke patients(23,24), a subject that has recently attracted attention.

It is difficult to extend the significance of the results of this study. The number of subjects was too small for the results to be generalized for the elderly with restrictive lung diseases, and the elderly can be affected by several variables, based on their physical and cognitive functions.

In this study, we identified that thoracic cage mobilization may serve as a new intervention of respiratory rehabilitation for the elderly with restrictive lung diseases. Thoracic cage mobilization, as used in this study, may be recommended for clinically improving both respiratory function and posture of the elderly with restrictive lung diseases.

CONCLUSIONS

In conclusion, the thoracic cage mobilization used in this study may be an effective intervention in simultaneously improving respiratory function, spinal curve, and spinal movement of the elderly with restrictive lung diseases.

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