

Effect of thorax correction exercises on flexed posture and chest function in older women with age-related hyperkyphosis

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Abstract. [Purpose] The purpose of this study was to determine the effects of thorax correction exercises on flexed posture and chest function in older women with age-related hyperkyphosis. [Subjects and Methods] The study participants included 41 elderly women who were divided into a thorax correction exercise group (n = 20) and a control group (n = 21). Participants in the exercise group completed a specific exercise program that included breathing correction, thorax mobility, thorax stability, and thorax alignment training performed twice per week, 1 hour each session, for 8 weeks. Outcome measures included the flexed posture (thoracic kyphosis angle, forward head posture) and chest function (vital capacity, forced expiratory volume in a second, and chest expansion length). [Results] Participants in the thorax correction exercise group demonstrated significantly greater improvements in thoracic kyphosis angle, forward head, and chest expansion than those in the control group. [Conclusion] This study provides a promising exercise intervention that may improve flexed posture and chest function in older women with age-related hyperkyphosis.

Key words: Chest function, Flexed posture, Hyperkyphosis

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INTRODUCTION

Age-related hyperkyphosis (ARH) is an exaggerated anterior curvature of the thoracic spine that is associated with aging and frequently observed in older women¹⁾. ARH occurs commonly in women older than 55 years, regardless of vertebral fractures, with the incidence increasing 6–11% for every 10 years of increasing age²⁾. ARH is multifactorial, and although the precise etiology is not fully understood, poor posture, dehydration of the intervertebral disks, and reduced back extensor muscle strength have been reported as general causes of ARH^{1, 3)}.

Elderly women with ARH often report difficulties with physical performance because of changes in vertebral column alignment, which affects the quality of life of patients in relation to their health⁴⁾. In addition, ARH limits the movement of the rib cage, which is connected to the thoracic spine, resulting in difficulties with pulmonary function⁵⁾. Horie et al.⁵⁾ reported that the thoracic vertebrae forms costovertebral joints with the head of the rib. That are directly connected to the rib cage, suggesting there is

a close relationship with the expansion capabilities of the rib cage during inhalation. Although changes in vertebral column alignment in elderly women are clinically important to health and quality of life, ARH is considered important to only a small number of clinicians, and a basic protocol for the treatment of ARH has only recently been released⁶⁾.

Therapeutic exercises for ARH include back extensor strengthening and flexibility exercises as well as postural training to improve postural awareness⁷⁾. However, most currently available exercise strategies apply only a single exercise or combine exercises that target the whole body but do not focus on the thorax (i.e., the main structure that is deformed because of kyphosis). In addition, most studies have concentrated on measurement of the thoracic kyphosis angle, muscle strength, range of motion, and physical performance after an intervention^{7, 8)}, and few studies have been conducted on measurement of chest functions.

Thus, this study applied a thorax correction exercise program for 8 weeks in elderly women with ARH aged more than 65 years old and verified the effect of the exercises on flexed posture and chest function with the purpose of providing a therapeutic intervention that can manage and prevent the health risks of women with ARH.

SUBJECTS AND METHODS

This study was conducted on 41 elderly women with ARH aged over 65 years living in D Metropolitan City (experimental group, 20 women; control group, 21 women).

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The selection criteria were as follows: thoracic kyphosis angle of more than 45°, reduced respiratory function (forced vital capacity [FVC] <80% predicted value) with <3 cm of chest expansion, ability to decrease kyphosis by 5° or more in the standing posture, and ability to walk independently both on flat surfaces and ascending stairs. Individuals were excluded if they were diagnosed with vertebral compression fractures within 6 months of the study, they had a cardiac or respiratory disease, or they were unable to perform the exercise program because of mental problems (e.g., dementia) or reduced cognitive ability (Mini-Mental State Examination score ≤ 24). All included patients understood the purpose of this study and provided written informed consent prior to participation in accordance with the ethical standards of the Declaration of Helsinki.

Each measurement was conducted twice in 2 postures: usual and best straight postures. The usual posture was defined as a relaxed posture, and the measurements were taken at the time of full exhalation. On the other hand, the best straight posture was the optimal posture during full inhalation, in which the participants exhibited their tallest height and the spine was as straight as possible. Thoracic kyphosis was measured using 2 gravity-dependent inclinometers (Isomed Inc., Portland, OR, USA) placed over the spinal processes of T1 and T2, and over the T12 and L1 vertebrae. The thoracic kyphosis angle was measured and recorded by checking the angles displayed on the inclinometers⁸. Forward head posture was measured as the distance between the wall and the tip of the tragus. To prevent the participants' trunks from leaning forward, their heels were attached to a 5-cm block while their knees were extended as much as possible and their heads were maintained at the neutral position during measurement.

Chest functions were assessed using the flow volume and chest expansion length, with the flow volume measured as the vital capacity (VC) and forced expiratory volume in 1 second (FEV1) using an electronic spirometer (Jaeger MaterScope, CareFusion, Wurzburg, Germany). To increase the measurement accuracy, a nasal clip and mouthpiece were applied to avoid air leaking during the measurements. To measure VC and FEV1, the participants started by breathing at rest after the completion of zero adjustment. Participants then inhaled slowly to within their maximal range and exhaled with their full force until they were instructed to stop by the sound of a beeper. Participants repeated several trials of this measurement, and all measurements were conducted while the participants were comfortably seated in a chair with arm and back rests. In addition, to evaluate the chest expansion length, the difference between the circumference of the thorax between inhalation and exhalation in the maximal range was measured at the level of the tenth rib using a flat measuring tape⁹. All measurements were conducted 3 times, and the average was used as the final value.

The experimental group was required to participate in the thorax correction exercises for 60 minutes in total, consisting of a 5-minute warm-up and 5-minute cool-down period and 50 minutes of primary exercises. The exercises were conducted twice a week for 8 weeks in a group exercise setting. With respect to the control group, the participants were required to participate in a daily exercise training program

Table 1. General characteristics of subjects

Variables	Experimental group (n ₁ =20)	Control group (n ₁ =21)
Age (years)	73.7±5.6	76.4±6.6
Height (cm)	150.4±5.5	151.1±5.7
Weight (kg)	58.6±7.7	54.4±7.0

Values are mean±SD

consisting of the same exercises as the experiment group. The exercises were provided to the participants in a booklet that contained all of the exercise-related information. The thorax correction exercise aimed to correct the thorax, which is the structure most affected by thoracic kyphosis, in contrast to existing thorax improvement exercise. The program consisted of 4 sub-exercises including 5 minutes of breathing correction, 15 minutes of thorax mobility, 20 minutes of thorax stability, and 10 minutes of thorax alignment reorganization exercise.

The 8-week exercise program was structured to include an adjustment phase for 1–2 weeks, an improvement phase for 3–5 weeks, and a maintenance phase for 6–7 weeks with the aim of gradually improving posture and strength. Exercises to strengthen the back utilized elastic bands that were applied according to the principle of high-intensity progressive resistance exercise. The elastic band (Thera-Band, Hygenic Corporation, Akron, OH, USA) used in this study was a yellow band (15 cm wide, 70 cm long) with 1.8 kg of resistance. When participants were able to perform the exercise using the band for 3 sets of 8 repetitions without any pain and discomfort, the yellow band was replaced with a red band with 2.7 kg of resistance¹⁰.

The collected data were statistically processed using SPSS version 18.0; general participant characteristics are presented as means and standard deviations using descriptive statistics analyses. The Shapiro-Wilk test was conducted to verify normality. To compare the flexed posture and chest function variables between the experimental and control groups before and after the exercise program, a paired-sample t-test was conducted, whereas an independent sample t-test was conducted to compare differences between groups. The statistical significance level for hypothesis testing was set at $\alpha = 0.05$.

RESULTS

The mean age, height, and weight of the experimental group (n=20) were 73.8 years, 150.4 cm, and 57.7 kg respectively, whereas the values in the control group were 76.4 years, 151.1 cm, and 54.4 kg, respectively, with no statistical differences between the treatment groups (Table 1). Regarding differences in flexed posture variables between the 2 groups before and after the intervention, statistically significant differences were noted for the kyphosis angle and forward head variables for the best and usual postures ($p < 0.05$; Table 2). VC and FEV1 were not significantly different between the 2 groups before and after the intervention ($p > 0.05$), whereas the chest expansion length was statistically different between the groups ($p < 0.05$; Table 3).

Table 2. Comparison of pre- and post-intervention flexed posture variables

Variable	Experimental group (n ₁ =20)			Control group (n ₁ =21)		
	Pre	Post	Change	Pre	Post	Change
Kyphosis angle: usual (deg)	57.2±2.8	53.5±3.6	3.4±2.1*	55.8±4.7	53.9±5.0	1.9±2.1*†
Kyphosis angle: best (deg)	53.2±3.3	49.7±2.9	3.5±1.6*	51.9±3.3	50.7±4.5	0.1±2.0†
Forward head: usual (cm)	17.7±1.8	15.9±1.9	1.7±0.3*	17.1±1.8	16.1±1.8	0.9±1.0†
Forward head: best (cm)	16.0±2.0	14.2±1.6	1.7±0.7*	15.7±1.8	14.7±1.8	1.0±1.3†

Values are means ± SD. *Significant difference between pre- and post- intervention values within a group (p<0.05), †Significant difference in change value between groups (p<0.05)

Table 3. Comparison pre- and post-intervention chest function variables

Variable	Experimental group (n ₁ =20)			Control group (n ₁ =21)		
	Pre	Post	Change	Pre	Post	Change
VC (l)	2.2±0.2	2.2±0.1	0.03±0.15	2.2±0.1	2.3±0.2	0.3±0.2
FEV ₁ (l)	1.7±0.1	1.8±0.1	0.1±0.1	1.8±0.2	1.8±0.1	0.1±0.1
Chest expansion length (cm)	1.7±0.5	2.1±0.5	0.4±0.2*	1.6±0.9	1.7±0.9	0.1±0.3†

Values are means ± SD. *Significant difference between pre- and post- intervention values within a group (p<0.05), †Significant difference in change value between groups (p<0.05)

DISCUSSION

This study was conducted with elderly women whose thoracic kyphosis had increased more than 45° to determine the effect of an 8-week thorax correction exercise program on flexed postures and chest functions. The results illustrated that the thorax correction exercises were effective in improving the flexed postures and chest expansion ability.

Thoracic kyphosis was improved by 3.45° in the usual posture and 3.50° in the best posture after the intervention. A study by Katzman et al.⁷⁾, who aimed to improve multiple musculoskeletal impairments in elderly women with hyperkyphosis, reported that a 12-week complex exercise program including flexibility and strength exercises of the joints and muscles in the upper and lower extremities decreased thoracic kyphosis by 6° in the usual posture and 5° in the best posture. Greendale et al.¹⁰⁾ also aimed to improve hyperkyphosis and reported improvements of thoracic kyphosis when Hatha yoga was applied 3 times a week for 24 months. This suggests that exercise methods designed to improve the symptoms of thoracic kyphosis are conducive to improving the structural alignment and stiffness of the thorax as well as to correcting thorax position. In the forward head posture, the experimental group experienced improvements in thoracic kyphosis of 11.63% in the usual posture and 12.28% in the best posture after the intervention. Balzini et al.⁴⁾ explained that increased hyperkyphosis and forward head postures were the characteristics of flexed postures of elderly women, and the improvement of forward head posture improved the flexed positions.

In addition, a 24.27% improvement in chest expansion, which refers to the mobility of the rib cage in chest functions, was found. However, VC and FEV₁ were not significantly different between and within groups before and after the intervention. Horie et al.⁵⁾ measured respiratory function using FVC and % FVC and reported that the lumbar lordosis

angle was more related to vertebral column alignment than thoracic kyphosis. In the present study, although the thorax improvement exercise program was not sufficient for improving flow volume, it was deemed effective in improving mobility of the rib cage.

The exercise program described in this study was developed to improve the mobility and stability of the ribs and thorax, focusing on anatomical and kinematic improvements in the rib cage, where the structural deformity of hyperkyphosis was most prominent. Itoi and Sinaki¹²⁾ conducted a back extensor muscle strengthening exercise intervention with hyperkyphotic elderly women in which participants wore a backpack in the prone position, however, this exercise only focused on strengthening the back extensor muscles. Furthermore, a study by Greendale et al.¹¹⁾ applied Hatha yoga, consisting of 4 postures, which aimed to strengthen the core and extensor muscles, improve the flexibility of the muscles around the shoulder and hips, and teach the participants postures. However, these exercises were not able to elicit a specific effect on thorax correction because they were not specific to the affected part of the body. In response to this, the present study implemented a thorax correction exercise program that considered the structural characteristics of the participants, with a focus on the rib cage.

There were several limitations associated with the present study. First, it is difficult to generalize the results because they focus exclusively on women over the age of 65 years living in a single region. In addition, the physical activities of the participants other than the prescribed 8-week exercise program were not controlled. Therefore, our future work will focus on expanding this project to males and other regions as well as on incorporating elderly participants with different types of hyperkyphosis. Furthermore, the application of a variety of intervention programs should also be studied in future research. Moreover, dynamic postural analysis and functional performance evaluation, aside from static pos-

tures, need to be included so that the effect of thorax correction exercises can be verified from a variety of perspectives.

In summary, the exercise methods developed in the present study can be recommended for improving the mobility of the rib cage and postures through specialized exercises focused on thorax posture correction in elderly women with hyperkyphosis.

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