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Original Article

Effects of Swiss ball exercise and resistance exercise on respiratory function and trunk control ability in patients with scoliosis

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Abstract. [Purpose] This study compared the effects of Swiss ball exercise and resistance exercise on the respiratory function and trunk control ability of patients with scoliosis. [Subjects] Forty scoliosis patients were randomly divided into the Swiss ball exercise group (n= 20) and resistance exercise group (n = 20). [Methods] The Swiss ball and resistance exercise groups performed chest expansion and breathing exercises with a Swiss ball and a therapist's resistance, respectively. Both groups received training 30 min per day, 5 times per week for 8 weeks. [Results] Both groups exhibited significant changes in forced vital capacity, forced expiratory volume in one second, and trunk impairment scale after the intervention. However, there was no significant change in the forced expiratory volume in one second/forced vital capacity ratio after the intervention in either group. Meanwhile, forced expiratory volume in one second and trunk impairment scale were significantly greater in the resistance exercise group after the intervention. [Conclusion] Both Swiss ball exercise and resistance exercise are effective for improving the respiratory function and trunk control ability of patients with scoliosis. However, resistance exercise is more effective for increasing the forced expiratory volume in one second and trunk control ability.
Key words: Scoliosis, Respiratory function, Trunk control ability

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INTRODUCTION

An increasing number of patients are visiting hospitals owing to abnormal posture and idiopathic spinal deformities. Such conditions are especially serious for adolescents, who are undergoing dramatic musculoskeletal growth. This problem appears closely related to lifestyle issues such as learning environment and lack of exercise[1)].

Scoliosis, the most common spinal deformity, is characterized by the spine deviating laterally from the center axis and rotating. Scoliosis causes both exterior deformity and decreased respiratory muscle contraction, restricting movements of the costal bones and trunk. This can progressively exacerbate cardiopulmonary function disorders and cause complications such as backache. Moreover, the deformity can transpose or press surrounding organs, resulting in functional disorder and decreased lifespan[2)]. In addition, scoliosis can decrease lung volume, diminishing lung function[3)]. Therefore, treatment aiming to correct trunk alignment, stimulate trunk movement during respiration, and improve respiratory function is mandatory[4)].

Both surgical methods and non-surgical conservative treatments have been used to treat idiopathic scoliosis[5)]. Conservative treatments include wearing an orthosis[6, 7)], exercise therapy while wearing a Milwaukee orthosis[8)], wearing a Boston orthosis[9)], electrical stimulation therapy[10)], extension therapy[11)], and exercise therapy[12)].

Traditional exercise therapy methods for scoliosis treatment include postural exercises, stretching, muscle strengthening exercises, respiratory training, and muscle strength imbalance correction exercises[2, 13)].

Exercise methods for idiopathic scoliosis have been used for a long time; they are typically used to stimulate trunk stability and symmetric development by stretching shortened muscles and strengthening trunk muscles. Although these exercise methods have limitations in their ability to arrest and correct moderate or severe scoliosis, they are effective for mild scoliosis or when performed in conjunction with an orthosis or traction treatment[13)]. There are many reports on the effectiveness of exercise therapies for scoliosis treatment[14–18)]. However, until recently, scoliosis treatment was decided mainly on the basis of the level of deformation and speed of progression, with little or no regard to its effect on cardiopulmonary function.

Therefore, the present study evaluated and compared the effects of Swiss ball exercise and resistance exercise on respiratory function and trunk control in patients with scoliosis.

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SUBJECTS AND METHODS

The patients were outpatients at N Hospital in Daegu, South Korea who had been diagnosed with scoliosis and agreed to participate in the study. Among the chest and pelvic X-ray images of 49 patients with scoliosis, 42 patients had Cobb angles between 10° and 20°. Among them, 40 patients who agreed to participate and met the following inclusion criteria participated in the experiment. The inclusion criteria were as follows: absence of any lung diseases before scoliosis, no congenital chest deformation or rib fracture, and ability to sit independently. All 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.

The patients were randomly divided into the Swiss ball exercise group (SEG, n = 20) and the resistance exercise group (REG, n = 20). Both groups completed 30 minutes of exercise per day, 5 times per week for 8 weeks.

The SEG performed a warm-up, stretching, main exercise, and cool-down exercises as described previously by Kim and Yang[19]. Chest and waist stretching were performed for 5 minutes each, focusing on stretching the concave side. Stretching was conducted in two positions. First, the patient lay on one side to perform stretching. Next, they dropped to their knees while holding a Swiss ball, bent their waist, and turned in the opposite direction from the convex side. They maintained the stretching position for 10 seconds each time. Main exercises were performed for 20 minutes. The patient put both hands on their head, lay on a Swiss ball on the opposite side of the superior convex side, and twisted their trunk toward the opposite side. Next, they sat on a ball, put their hands on their pelvis, placed both feet on the ground, and bounced using the elasticity of the ball. Patients put both legs on the ball, supporting themselves on the ground using their hands, and moved their legs and the ball from side to side. In the side-lying-on-elbow position, the patient supported themselves with one hand on the ground and pushed a ball using the other hand, stretching their trunk. Thoracic resistance exercise was performed for 10 minutes. The patient lay on one side, and the therapist placed their hands on the part of the patient's chest on which they wished to focus. In synchrony with the patient's respiration rhythm, the therapist exerted pressure while tracing an arc along the costal line in a downward and inward direction. The diaphragm movement was facilitated by a therapist. The therapist directly facilitated the diaphragm using their thumb or other fingers to push below the thorax upward and outward. Resistance was provided to the contracting diaphragm's movement, downwards and stretching. For indirect facilitation, the therapist placed both hands on the abdomen and applied light pressure toward the upper side while the patient inhaled.

Meanwhile, the REG performed stretching, main exercises, and cool-down as described previously by Lim et al[20]. All exercises were performed under a therapist's guidance.

Chest stretching and waist stretching were performed for 5 minutes each. The patient lay on their side with the convex side of chest and waist below, with a thick towel at the apex of the curve. The waist remained in contact with the ground, and the patient held their arms up to stretch. The stretching position was maintained for 10 seconds and repeated 15 times. Next, main exercises were performed for 15 minutes. In the supine position, the patient bent both legs such that they could pull them toward the chest. The therapist held the patient's knees to provide resistance, enabling the patient's abdominal muscles to be fully stimulated.

Table 1. General characteristics

		SEG (n = 20)	REG (n = 20)
Gender	Female	15	16
	Male	5	4
Age (years)		18.5 ± 1.2	17.9 ± 1.1
Height (cm)		162.3 ± 8.5	163.1 ± 7.0
Weight (kg)		56.7 ± 10.8	54.9 ± 6.0

Data are mean ± SD. SEG: Swiss ball exercise group, REG: resistance exercise group. $p > 0.05$.

In the hook lying position, patients performed a bridge exercise designed to lift the hips. The therapist held the patient's pelvis and induced posterior tilt to provide resistance. In the side-lying position, the patient raised their leg on the upper side. The therapist held the femoral region, providing resistance as the patient moved and stimulating movement. In a sitting position, the patient bent the knee on the waist on the concave side to 90°, and the therapist provided resistance to raise the leg. Thoracic resistance exercise was performed for 10 minutes. The patient lay on one side, and the therapist placed their hands on the part of the patient's chest they wished to focus. In synchrony with the patient's respiration rhythm, the therapist exerted pressure while tracing an arc along the costal line in a downward and inward direction. The diaphragm movement was facilitated by a therapist. The therapist directly facilitated the diaphragm using his thumb or other fingers to push below the thorax in an upward and outward direction. Downward resistance was provided to the contracting diaphragm's movement to induce stretching. For indirect facilitation, the therapist placed both hands on the abdomen and applied light pressure toward the upper side while the patient inhaled.

All patients underwent preliminary evaluation before the exercise program and were re-evaluated after 8 weeks.

Forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and peak expiratory flow were measured by a Cardio Touch 3000S(BIONET,US) and trunk control ability was evaluated according to the trunk impairment scale (TIS).

Patients' general characteristics were analyzed using descriptive statistics. A paired t-test was used to assess differences pre- and post-intervention. An independent-sample t-test was used to assess difference between the two groups. The level of significance was set at $p < 0.05$. SPSS version 12.0 was used for statistical analysis.

RESULTS

There were no significant difference in the baseline general characteristics between the SEG and REG (Table 1).

Table 2. Respiratory function and trunk control ability

	Swiss ball exercise group		Resistance exercise group	
	Pre	Post	Pre	Post
FVC (L)	2.3 ± 1.0	3.0 ± 1.2*	1.9 ± 0.9	2.8 ± 0.7*
FEV1 (L)	1.8 ± 0.7	2.2 ± 0.9*	1.5 ± 2.3	2.3 ± 0.5*†
FEV1/FVC (%)	84.7 ± 23.7	79.4 ± 21.2	80.2 ± 17.6	85.0 ± 11.2
TIS	11.6 ± 1.2	12.3 ± 1.2*	11.6 ± 0.9	14.0 ± 0.9*†

*p < 0.05 vs. pre-intervention. †p < 0.05 between groups. FVC: forced volume vital capacity, FEV1: forced expiratory volume in one second, TIS: trunk impairment scale

Both groups showed significant differences in FVC, FEV1, and the TIS after the intervention ($p < 0.05$). However, the FEV1/FVC ratio did not differ significantly in either group after the intervention ($p > 0.05$).

When comparing the two groups, FEV1/FVC did not differ significantly between groups before or after the intervention ($p > 0.05$). However, FEV1 and the TIS were significantly greater in the REG than the SEG after the intervention ($p < 0.05$) (Table 2).

DISCUSSION

This study was aimed to verify and compare the effectiveness of Swiss ball exercise and resistance exercise on respiratory function and trunk control ability in scoliosis patients. FVC, FEV1, and FEV1/FVC were measured to assess respiratory function, and the TIS was used to assess trunk control ability.

Fabian[21] applied asymmetric respiration exercise-type physical therapy to 30 female idiopathic scoliosis patients aged between 14 and 16 years for 4–5 weeks and reported that respiratory function and thorax movement improved significantly. Meanwhile, Alves et al.[22] applied physical therapy for 4 months to high-level idiopathic scoliosis patients whose thoracic curvature was between 45° and 88°; patients exhibited improvements in FVC, inspiratory capacity, FEV1, expiratory reserve volume, and 6-minute walking test results. Dyner-Jama et al.[23] applied asymmetric respiration exercises to scoliosis patients for 24 days and reported significant improvements in FVC and FEV1. Weiss[24] applied the Schroth method to idiopathic scoliosis patients and reported a 13–18% improvement in vital capacity and 20% average improvement in chest expansion.

Concordant with the abovementioned studies, the present study also showed significant improvements in FVC, FEV1, and the TIS after both exercise interventions.

Improved respiratory functions and trunk control ability appear to be due to improved adaptability in unstable posture, as the Swiss ball exercise is conducted on a dilatational ball. The development of respiratory muscles and muscles around the spine as well as improved posture control ability may have affected the results.

These findings are also concordant with the study of Creager[25], who reports Swiss ball exercise is effective for developing muscle strength around the waist, increasing waist flexibility, improving coordination, and stimulating proprioceptors and the cardiovascular system.

Resistance exercise improves respiratory function and trunk control ability, growing the muscles causing the abnormality specifically by lengthening shortened muscles and increasing the strength of the weakened muscles that created the resistance. By performing this exercise, patients are likely to achieve improved flexibility and muscle strength of the respiratory muscles and muscles around the spine. Trunk stability and symmetric development may have also improved respiratory functions and trunk control ability.

FEV1 and the TIS were significantly greater after the resistance exercise than the Swiss ball exercise, suggesting the therapist's application of direct resistance more strongly influences respiratory muscles and the muscles surrounding the spine. In particular, resistance exercise may have had a greater effect on the abdominal muscles that move during expiration.

A major limitation of this study is the small sample size, meaning the results cannot immediately be generalized. Therefore, studies evaluating these treatments in more patients and over a longer period are required. Future follow-up studies must also evaluate the improvement of muscle strength related to respiration and trunk stability. In addition, it is essential to investigate the durability of the effects of these exercises.

In conclusion, Swiss ball exercise and resistance exercise can improve scoliosis patients' respiratory functions and trunk control ability, although resistance exercise is more effective for improving FEV1 and the TIS.

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