The effect of Swiss ball exercise and resistance exercise on balancing ability of scoliosis patients

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Abstract. [Purpose] The purpose of the study was to closely examine the efficiency of Swiss ball exercise and resistance exercise in improving the on the static balancing ability by applying them to patients with scoliosis and to compare the effects of the interventions. [Subjects] Forty scoliosis patients were divided into a Swiss ball exercise group (SEG, N = 20) and a Resistance exercise group (REG, N = 20) randomly. [Methods] SEG conducted chest stretching, trunk exercise using the Swiss ball. REG conducted chest stretching, trunk exercise with therapist’s resistance. Both groups received training 30 min per day, five times per week, for eight weeks. [Results] Both SEG and REG showed significant differences between pre- and post-mediation in terms of weight distribution, sway area, sway length, sway speed, and limit of stability. Sway speed and limit of stability had increased more significantly in REG than in SEG. [Conclusion] According to the result of this study, both Swiss ball exercise and chest Resistance exercise were effective for improving on the static balancing ability. But we suggest resistance exercise is more efficient to increase of sway speed, limit of stability.

Key words: Scoliosis, Swiss ball exercise, Resistance exercise

INTRODUCTION

The term scoliosis was first used by Galen (AD 131–201) and is defined as one or more than two spines lean laterally and placed on the side or rotate. Bunnell defined the structural change of Cobb angle over 10 degrees as idiopathic scoliosis. In addition, it is accompanied by coronal deformity in which the spine curves or deviates laterally from anatomical center with rotated centrum deformation. Moreover, the spine loses its normal curve on the sagittal plane, leading to three-dimensional deformity.

Scoliosis is accompanied by the following symptoms: tilted head caused by unbalanced hip joint and distorted trunk, unbalanced neck line due to tilted trunk, and scapular winging. Moreover, it can cause disparity of pelvis and shoulder height as well as in length of legs. Severe scoliosis can cause decreased muscle strength and flexibility as well as muscle rigidity and pain, so that a patient may experience fatigue when sitting or standing for a long time, and cardio-pulmonary function may decrease. Scoliosis may also cause problems in external appearance, resulting in psychological and social problems.

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exercises, respiratory training, and muscle strength imbalance correction exercises. These exercises improve spinal flexibility, strengthen muscles around spine, and correct muscle imbalance\(^9\). Various exercise programs have previously been studied and their effects reported\(^{10-18}\). For such programs, equipment such as the Swiss ball and the sling are quite often used. However, few studies have compared exercise programs and active exercise programs in terms of their use of equipment, how well they stimulate muscle contraction, and whether they are effective in improving scoliosis patients’ balancing ability. For that reason, the present study investigates the effect of Swiss ball exercise and resistance exercise on the static balancing ability of scoliosis patients.

**SUBJECTS AND METHODS**

The subjects of this study were outpatients at N Hospital in Daegu who had been diagnosed with scoliosis and agreed to participate in the study. From 57 scoliosis patients’ chest and waist X-ray results, 43 patients were identified with between 10 and 20 degrees of Cobb’s. Of these, 40 patients who were willing to participate and met the study requirements took part in the experiment. The inclusion criteria were absence of any special lung diseases before scoliosis, no congenital chest deformation or rib fracture, and the ability to sit independently. All the subjects understood the purpose of this study and provided their written informed consent prior to their participation in the study, in accordance with the ethical standards of the Declaration of Helsinki.

The participants (N = 40) 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 each day, 5 times a week for 8 weeks.

The SEG performed a warm-up, stretching, main exercise, and cool-down exercises as described previously by Kim and Yang\(^{17}\). 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 Rhim et al\(^{18}\). 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. 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 participants underwent preliminary evaluation before the exercise program and were evaluated again after 8 weeks. For measurement of balance ability, a biofeedback analysis system (AP1153 Bioreusc, France) was used to determine center of gravity (COG) and limit of stability in a static standing position.

Subjects’ general characteristics were analyzed using descriptive statistics. A paired t-test was used to assess any difference between pre- and post-experiment. Independent sample t-testing was used to assess any difference between the two groups. Significance level was set at \(p < 0.05\). SPSS v. 12.0 was used for statistical analysis of the data.

**RESULTS**

No significant difference in general characteristics was found between SEG and REG (Table 1). Both SEG and
REG showed significant differences in terms of weight distribution, sway area, sway length, sway speed, and limit of stability (p < 0.05).

When the two groups were compared in terms of differences in pre- and post-mediation, there was no significant difference between the groups in terms of weight distribution, sway area, and sway length before and after (p > 0.05). However, sway speed and limit of stability had increased more significantly in REG than in SEG (p < 0.05) (Table 2).

**DISCUSSION**

Scoliosis is defined as a condition in which curvature of the spinal column accompanies rotation and departure from the vertical line. It is generally related to rotation of spine. When the vertebral angle is at least 10 degrees or more on the front back radiography, it is defined as scoliosis. There are many causes of scoliosis, and the curve appears to be a secondary cause. Deformation of the spine and asymmetry of the chest wall and back generally appear in similar manner. Scoliosis is identified by the patient, their parents, by schools, of the chest and foot. According to earlier studies, secondary problems can occur when scoliosis accompanies muscle strength imbalance and abnormal posture, requiring patients to actively participate in voluntary exercise programs.

There are many treatments and methods of mediation for scoliosis. The various treatment methods include therapeutic exercise, orthosis, electrical stimulation, manual therapy, physical therapy, and foot adjusters. Some of these are not adequate as treatments; for example, electrical stimulation is not effective in stopping curve increase or turning the curve to the opposite side. However, exercise-based treatment has attracted increasing interest in the literature and there is some evidence of its effectiveness.

The present study was conducted to verify the effectiveness of Swiss ball exercise and resistance exercise on scoliosis patients’ balancing ability, and to compare the effects of the two exercise programs.

To check balancing ability, the study measured weight distribution difference, sway area, sway length, sway speed, and limit of stability. Shin and Song conducted research with 20 idiopathic scoliosis patients on balancing while standing. The subjects performed a waist stabilization exercise for 40 minutes, 3 times a week for 3 weeks. When pre- and post-treatment performance was compared, improved balancing ability was reported, due to decreased sway length and sway speed. Gong Won Tae et al. conducted research on 20 normal people balancing while standing. The subjects performed waist stabilization exercises for 30 minutes, 3 times a week for 3 weeks. When they compared the experimental group with the control group (who did not perform the exercise), the experimental group showed a significant increase in balancing ability. Park employed a sling with scoliosis patients performing a waist stabilization exercise. The subjects showed significantly decreased sway and surging, both with eyes opened and eyes closed. Lim conducted 12 weeks of lower limb-strengthening training and gait pattern training with female scoliosis patients who were high school students. In her study, plantar pressure difference between left and right as well as body balancing ability improved significantly after training.

In the present study, SEG and REG both showed significant improvement in weight distribution difference, sway area, sway length, sway speed, and limit of stability after the exercise program, which is similar to results from preceding studies.

Improved balancing ability indices after the Swiss ball exercise seem to be the result of improved adaptability in unstable posture, as the Swiss ball exercise is conducted on a dilatational ball. These findings are also in line with Creager’s study, which reported that Swiss ball exercise is effective in developing muscle strength around the waist, increasing waist flexibility and improving coordination, and stimulating proprioceptors and the cardiovascular system.

In the present case, balancing ability indices were found to have improved after the resistance exercise. This seems to be explained by improved trunk stability and symmetric development supported by strengthened muscles around the spine. Shortened muscles were stretched and weakened.

**Table 1. General characteristics of subjects (M±SD)**

|          | SEG (n=20) | REG (n=20) |
|----------|------------|------------|
| Gender   | female 14  | 13         |
|          | male 6     | 7          |
| Age (years) | 18.39±1.15 | 17.78±1.06 |
| Height (cm) | 161.88±8.54 | 163.38±7.03 |
| Weight (kg) | 58.68±10.77 | 54.66±6.03 |

M±SD: mean±standard deviation, SEG: Swiss ball exercise group, REG: Resistance exercise group

**Table 2. Comparison of change in balance function in the training groups (M±SD)**

|          | SEG          | REG          |          | SEG          | REG          |
|----------|--------------|--------------|----------|--------------|--------------|
|          | pre          | post         | pre      | post         |              |
| Differance of Rt. & Lt WB | 13.2±9.1 | 7.1±6.6* | 10.3±7.2 | 4.8±4.3* |
| Sway area (mm²) | 349.7±407.6 | 199.1±238.1* | 437.0±381.2 | 167.5±166.2* |
| Sway length (mm) | 36.7±14.9 | 30.6±11.2* | 42.5±16.9 | 33.9±10.2* |
| Sway speed (mm/s) | 0.7±0.2 | 0.6±0.198* | 0.8±0.3 | 0.5±0.2* |
| LOS (mm) | 2,361.1±2,299.5 | 3,002.1±2,629.2* | 4,235.5±4,644.7 | 7,064.3±5,014.4* |

*significant difference compared with before therapy at <0.05. **significant difference in gains between the two groups at <0.05. SEG: Swiss ball exercise group, REG: Resistance exercise group LOS: limit of stability
muscules provided with resistance were strengthened by means of muscle strengthening exercises.

In addition, the study results show that sway speed and limit of stability significantly improved in REG as compared to SEG. It seems that application of direct resistance by the therapist may have been more effective for symmetric development of muscles around the spine and for trunk stability.

Future studies should be conducted with more patients and over a longer period of time. In addition, it will be necessary to evaluate the level of improvement of muscle strength related to trunk stability, as well as the effect on muscle activity. It will also be important to establish how long the effects of exercise last.

The results of this study demonstrate that Swiss ball exercise and resistance exercise can both improve scoliosis patients’ balancing ability. Although resistance exercise was found to be the more effective method, both Swiss ball exercise and resistance exercise are considered to be effective mediation methods for improving scoliosis patients’ balancing ability.

REFERENCES

1) David S, Bradford MD, James W, et al.: Moe’s Textbook of scoliosis and other spinal deformities. Philadelphia: W.B. Saunders, 1994.
2) Bunnell WP: The natural history of idiopathic scoliosis before skeletal maturity. Spine, 1986, 11: 773–776. [Medline] [CrossRef]
3) Skaggs DL, Bassett GS: Screening for idiopathic adolescent scoliosis. Am Fam Physician, 1997, 55: 1073–1074. [Medline] [CrossRef]
4) Tones M, Moss N, Polly DW Jr: A review of quality of life and psychosocial issues in scoliosis. Spine, 2006, 31: 3027–3038. [Medline] [CrossRef]
5) Ford DM, Bagnall KM, Clements CA, et al.: Muscle spindles in the paraspinal musculature of patients with adolescent idiopathic scoliosis. Spine, 1988, 13: 461–465. [Medline] [CrossRef]
6) Nault ML, Allard P, Hinse S, et al.: Relations between standing stability and body posture parameters in adolescent idiopathic scoliosis. Spine, 2002, 27: 1911–1917. [Medline] [CrossRef]
7) Guo X, Chau WW, Hui-Chan CW, et al.: Balance control in adolescents with idiopathic scoliosis and disturbed somatosensory function. Spine, 2006, 31: E437–E440. [Medline] [CrossRef]