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Effects of Self-Traction Exercises on the Vertebral Alignment, Muscle Strength, and Flexibility of Adults in Their Twenties with Scoliosis

Background: Effect of cervical and lumbar tractions on the reduction in the angle of curvature and the effect of a correction exercise or a general traction method on balance, muscle strength, pain, and body alignment, however insufficient research has been undertaken on self traction exercises targeting patients with scoliosis.
Purpose: To determine the effect of cervical and lumbar tractions on the reduction in the angle of curvature and the effect of a correction exercise or a general traction method on balance, muscle strength, pain, and body alignment.
Design: Randomized controlled clinical trial (single blinded)
Methods: Twelve adults(20s) with scoliosis were included in this study and performed a traction program that was composed of a 5-min warm-up exercise, a 15-min main exercise, and a 5-min cool-down exercise (25 minutes in total), three times a week for four weeks. The Chiro traction machine was used for the self-traction exercise. Vertebral alignment, muscle strength, and flexibility were compared before and after the intervention using the paired T-test.
Results: The scoliosis angle, pelvic torsion, and lumbar extensor were significantly changed by intervention; however, there was no significant difference in flexibility.
Conclusion: The results revealed that self-traction exercise activated blood flow through the extension and contraction of muscles, effectively increasing the function of the muscles around the vertebrae.

Key words: *Self-traction, Scoliosis, Vertebral Alignment, Muscle Strength, Flexibility, Chiro Traction*

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INTRODUCTION

In the highly civilized modern society, as people's lives become more convenient, people have less time and effort to move their body, which leads to an increase of spinal diseases in modern people. [1] In addition, several factors related to the college admission-oriented education system in Korea, such as an increase in the time spent by elementary, middle, and high school students studying at their desks; a lack of physical activity; the maintenance of improper postures; and the lack of awareness of physical imbalance, have caused spinal deformation [2], which has become a serious health issue, not only for individuals but also for the entire society [3, 4].

Scoliosis refers to a structural change of 10° or more in Cobb's angle [5], which is defined as a condition where the spine is laterally displaced or rotated due to leaning of the spine at two or more positions to the lateral direction [6]. Scoliosis may cause eating disorders [7], decreases in bone density [8, 9], instability in the standing posture due to the change in interactions between the body segments, changes in the characteristics of the muscles around the spine due to vertebral deformation [10], an imbalance in the muscles around the spine [11], and a decrease in the amount of muscle spindles [12]. The treatment methods for scoliosis are broadly classified into surgical and conservative methods. The most common surgical methods for idiopathic scoliosis are translational maneuver and rod derotation along with pedicle screw fixation [13]. The conservative approaches include spinal traction and exercise therapy among the various physical therapy methods [14].

Spinal traction is classified into cervical traction and lumbar traction (depending on the traction site), continuous traction, sustained traction, and intermittent traction (depending on the traction method). Continuous traction and intermittent traction are often used in clinical practice [15]. Traction therapy relieves pain by stretching the vertebral structures and removing the stimulation or compression of the nerve roots, thereby lengthening the ligaments and muscles around the vertebrae, enlarging the inter-vertebral foramen, increasing the lumbar interbody intervals, widening the facet joint [16], and improving the scoliosis angle[17]. Because of these effects, traction therapy has been applied to patients with scoliosis in clinical practice, but many restrictions have been placed on the location and time for its application. Therefore, in this modern society, where home exercise education has become important in promoting self-health care, a study to investigate the effect of self-traction therapy on the reduction of the scoliosis angle and on vertebral alignment is needed.

Most of the previous researchers have investigated the effect of cervical and lumbar tractions on the reduction in the angle of curvature and the effect of a correction exercise or a general traction method on balance, muscle strength, pain, and body alignment, so insufficient research has been undertaken on self-traction exercises targeting patients with scoliosis. For this reason, this study aimed to investigate the effect of self-traction exercises on vertebral alignment, muscle strength, and the flexibility of adults in their 20s with scoliosis.

Study method

Study subjects and the selection of the subjects

For this study, 12 subjects who met the criteria for scoliosis were participated among the students attending N University located in Chungnam, South Korea. They enrolled in this study after fully understanding the purpose of this study and voluntarily participated.

To determine the degree of scoliotic curvature, the subjects were screened through the primary and secondary tests. Adam`s forward bending test was performed on 20 adults as a primary test. In the Adam`s forward bending test, the investigator stood at the back side of the subject, let the subject bend his or her back forward at about 90° to check the height of both shoulders and the shape of both shoulder bones (scapula) and then measured the angle at the maximum protruding part of the back with a scoliometer (Scoliosis Research Institute, Korea). The subjects showing an angle of 5° or greater in this test were classified into the eligible subject group. In general, when the measurement by a scoliometer is 5°, the vertebrae appear to be bent about 11° on the X-ray. Therefore, the subjects whose angle of trunk rotation was determined to be 5° or greater using a scoliometer were considered potential scoliosis positive group members [18].

In the secondary test, a three-dimensional image analyzer (Formetric 4D, DIERS International GmbH, Germany) was used. Among the subjects who passed the primary test, 12 adults showed a scoliosis angle greater than 10°, and these subjects were finally selected for this study.

Those with acute pain or persistent severe pain, spondylolysis or spondylolisthesis, and neurological paresthesia or muscle paralysis, and those with difficulty in exercising due to psychological problems or lack of comprehension were excluded.

Measuring instruments

A body composition analyzer (Inbody 720, Biospace, Korea) was used to identify the general characteristics of the subjects. A three-dimensional image analyzer (Formetric 4D, DIERS International GmbH Germany) was used to measure the subject's vertebral alignment, and a portable manual muscle testing machine (Power Track Ⅱ commander, Jtech medical. USA) was used to measure the subject's lumbar muscle strength. A forward trunk-hip joint flexion measuring instrument (DW-782 Flextion Meter, DSI, Korea) and a digital backward trunk-hip joint flexion measuring instrument (TKK5404, DK Science Instruments, Japan) were used to measure the flexibility of the subjects. A spinal traction exercise machine (Chiro traction, H & J Global Healthcare, Korea), which was a modified version of the Dorylax Pro improved in Korea to fit to the Korean body shape, was used to perform the self-traction exercise.

Study procedures

After the physical characteristics of the subject were identified, the vertebral alignment, strength, and flexibility of the subject were examined as pre-measurements. The subjects were assigned to a Chiro traction exercise group composed of 12 subjects. In this study, the traction program was composed of a warm-up exercise, a main exercise, and a cool-down exercise (25 minutes in total), and each session was performed three times a week for four weeks. The measurement was conducted after the 4-week program was completed (Figure 1). The meter did not know the contents of the study and only proceeded with the evaluation.

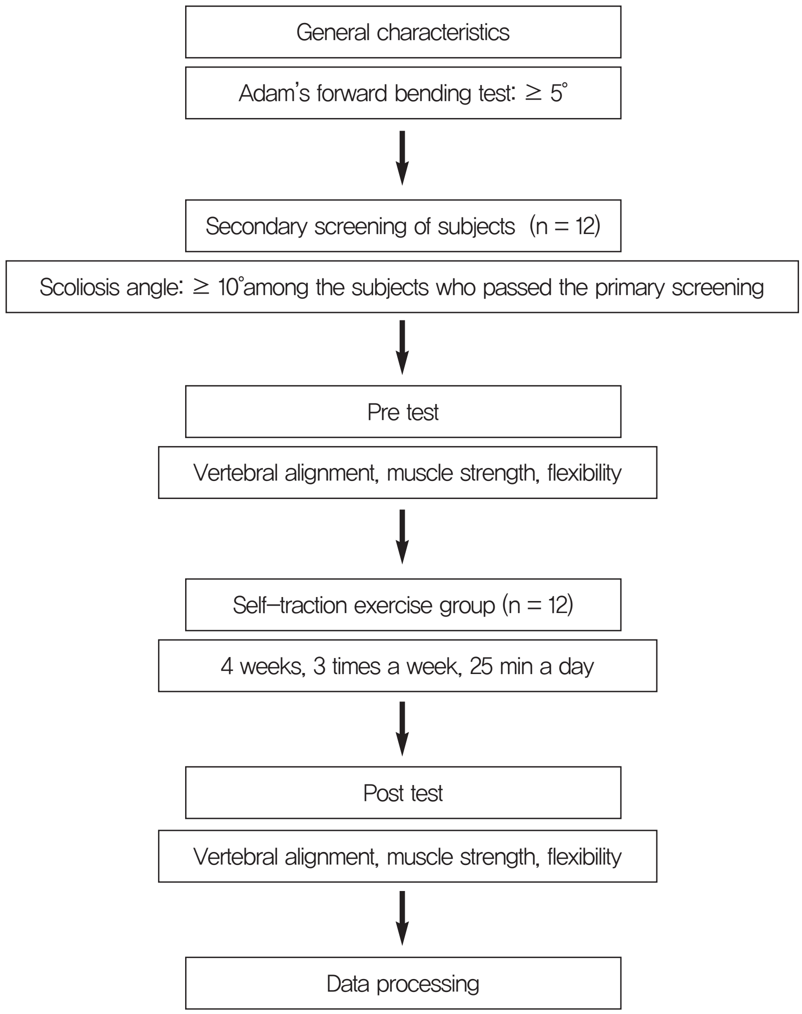

Fig. 1. Study design flow chart

The traction program was composed of a 5–min warm–up exercise, a 15–min main exercise, and a 5–min cool–down exercise (25 minutes in total). During the main exercise period, the self–traction exercise was performed 32reps for 4 min followed by 1 min of rest, and a total of three sets were performed. The subject adjusted the Chiro traction machine to his or her body shape and performed the self–traction exercise while lying down (Table 1).

Table 1. Self–traction exercise

Order	Self–traction method	Sessions	Time
Warm–up exercise	Stretching exercise (hip and waist)		5 min
Main exercise	1. Adjust the waist belt height to the body shape. 2. Adjust the axillary support to fit the chest circumference. 3. Adjust the leg spacings and the belt length. 4. Adjust the strength and number of pulling actions while lowering the upper body.	3 times	5 min
Cool–down exercise	Stretching exercise (hip and waist)		5min

Measuring methods

Vertebral alignment

The spinal three-dimensional (3D) image analyzer for analyzing vertebral alignment is an alternative to radiography for spinal structural analysis and is an instrument capable of analyzing vertebral alignment with a high reliability (r=.996) [19]. It is also an instrument for spinal structural analysis that can analyze the back surface of the trunk in three dimensions and identify a symmetrical line almost similar to the line abutting the vertical projection of the vertebrae by analyzing the curvature of the surface, thereby enabling a fast examination without radiation exposure. The predictive power of Formetric 4D for scoliosis has a high correlation with measuring the Cobb`s angle by X-ray.

For accurate measurements, the subjects were instructed to completely remove their tops, symmetrically align their heels in a straight line on the foot plate, turn their backs toward the camera, and lower their bottoms below the pelvis to expose the sacrum point.

For the data analysis of this study, the 4D average item—where the data values are expressed as the mean value of the data obtained from 12 frames of pictures taken for 6 seconds—was selected.

Muscle strength

To determine the lumbar muscle strength of the subject, the muscle strength of the lumbar extensor and flexor was measured using a portable manual muscle testing machine. To measure the muscle strength of the lumbar extensor, the subject placed his or her arms by the trunk in a prone position, with the measuring tool placed in the middle of the inferior angle of the scapula. To measure the muscle strength of the lumbar flexor, the subject placed his or her arms by the trunk in a supine position, with the measuring tool placed in the middle of the sternum. The subject was instructed to maintain isometric contraction for 3 seconds, which was repeated twice at intervals of 30 seconds, and the average was recorded [17].

Flexibility

To measure the flexibility of the lumbar extensor, the subjects were asked to bend their upper body forward while sitting down. They were then instructed to sit on the forward trunk-hip joint flexion measuring instrument with their knees fully extended and to bend their upper bodies forward as far as possible and hold for more than 2 seconds. After two measurements, the average was recorded.

To measure the flexibility of the lumbar flexor, the subjects were asked to bend their upper bodies backward in a prone position. Each subject was then instructed to take a prone position facing the floor with the arms placed behind the head and to lift the shoulders and head. Finally, the distance from the jaw to the right angle was measured twice, and the average value was recorded [20].

Data analysis

The data collected in this study were analyzed using SPSS ver. 20.0 for Windows. A paired T-test was used for a comparative analysis after the self-traction exercise intervention. The statistical significance was set to $\alpha = .05$.

RESULTS

General characteristics of the subjects

The general characteristics of the subjects in this study are as follows (Table 2).

Table 2. General characteristics of the subjects

Variable	means ± SD
Age (years)	20.75±0.96
Height (cm)	167.90±6.71
Weight (kg)	63.24±8.62
BMI (kg/m^2)	22.43±2.93
Sex (Male/Female)	5/7

SD: standard deviation

Results of the comparison of vertebral alignment

The results of the comparison of vertebral alignment after the self-traction exercise intervention revealed significant differences in the scoliosis angle and the pelvic torsion before and after the intervention ($p<.05$), but no significant difference was found in other variables (Table 4).

Results of the comparison of muscle strength

The results of the comparison of muscle strength after the self-traction exercise intervention revealed a significant difference in the muscle strength of the lumbar extensor before and after the intervention ($p<.05$), but no significant difference was found in the muscle strength of the lumbar flexor (Table 5).

Table 4. Changes in vertebral alignment after the self-traction exercise intervention

Variable	Pretest	Posttest	t	p
	Mean±SD	Mean±SD		
Scoliosis angle (°)	16.33±4.55	12.25±4.82	2.85	0.01*
Trunk length (mm)	446.50±23.76	451.58±33.01	−0.94	0.36
Dimple distance (mm)	89.58±16.70	97.75±10.81	−1.44	0.17
Trunk inclination (mm)	16.92±6.74	12.75±12.16	0.99	0.34
Trunk imbalance (mm)	8.50±8.27	8.92±6.84	−0.21	0.83
Pelvic tilt (°)	4.25±6.13	2.00±1.20	1.20	0.25
Pelvic torsion (°)	3.25±3.54	2.08±2.31	2.24	0.04*
Kyphotic angle (°)	38.58±19.26	39.17±8.08	−0.10	0.92
Kyphotic angle, T12 (°)	33.83±21.15	32.17±7.29	0.25	0.80
Lordotic angle (°)	41.17±20.09	33.83±8.44	1.44	0.17
Surface rotation (max+) (°)	3.33±4.51	5.42±3.37	−1.26	0.23
Surface rotation (max−) (°)	6.17±4.21	4.75±3.30	1.12	0.28
Lateral deviation (mm)	6.58±5.14	5.17±4.36	0.88	0.39

Values are shown as Mean ± SD.
*p<.05.

Table 5. Comparison of muscle strength within the group before/after the self-traction exercise intervention [kg]

Variable	Pretest	Posttest	f	p
Lumbar flexor	3.70±3.06	4.38±1.55	−1.04	0.32
Lumbar extensor	2.75±1.48	4.07±1.15	−2.59	0.02*

Values are shown as Mean ± standard deviation
*p<.05.

Table 6. Comparison of flexibility within the group before/after the self-traction exercise intervention [cm]

Variable	Pretest	Posttest	f	p
Forward bending of the upper body while sitting down	5.52±11.68	8.63±11.86	−1.37	0.19
Backward bending of the upper body in the prone position	29.38±6.60	32.27±7.01	−2.08	0.06

Values are shown as Mean ± standard deviation
*p<.05.

Results of the comparison of flexibility

The results of the comparison of flexibility after the self-traction exercise intervention revealed no significant differences in the forward and backward bending of the upper body (Table 6).

DISCUSSION

Scoliosis may occur by idiopathic or secondary causes. Idiopathic scoliosis is the most common form of scoliosis [21] and is characterized by an overall imbalance of muscles and appearance, such as trunk and thoracic deformities [22, 23]. The purpose of this study was to investigate the effect of a 4-week self-traction exercise on vertebral alignment, muscle strength, and flexibility.

The results of the comparative analysis of the changes in vertebral alignment within the group following the intervention revealed significant differences in the scoliosis angle and the pelvic torsion of the traction group after the intervention.

In a previous study, circuit weight training was applied to bowling athletes for 12 weeks, and then their vertebral alignments were analyzed; a significant difference in the pelvis torsion was found in the group subjected to the circuit weight training. The authors interpreted this to mean that the exercise performed in the study enhanced the spinal function in mobility and stability, resulting in a positive change in the spinal structure [24]. A previous study in patients with scoliosis reported that traction therapy was effective in reducing the angle of curvature. The authors interpreted this to mean that the traction exercise induced an indirect correction of the crooked scoliotic region and that the stretching exercise of the entire vertebrae, which was achieved through the stretching exercise of the soft tissue at the depressed area, was effective in the treatment of scoliosis. [17] In addition, another previous study reported that exercise and spinal traction were effective when the angle of curvature was less than 20° [25].

The significant differences observed in the self-traction exercise group before and after the interventions in this study are thought to have resulted from the stretching of the soft tissue and muscles at the scoliotic region by the self-traction exercise, which led to correction of the vertebral structures.

A comparative analysis of muscle strength before and after the intervention within the group revealed a significant difference in the lumbar extensor of the self-traction exercise group after the intervention.

In a previous study, where vertical traction and an exercise program were applied to patients with low back pain, a greater increase in the muscle strength of the lumbar extensor was observed in the experimental group subjected to vertical traction and the exercise program in combination than in the group subjected to the exercise program alone. The authors of this study interpreted this result as meaning that vertical traction induces a reduction in the pressure caused by gravity and soft tissues, vertebral separation, and extension of the disc and by the removal of negative pressure within the disc by eliminating the force exerted on the nucleus pulposus, thereby increasing the hydration of the disc and reducing the pressure on the nerve root [26].

In a previous study, where vertical traction therapy and MEDX exercise (general lumbar extensor strengthening exercise) were applied to female patients with low back pain for 8 weeks, the group subjected to the vertical traction therapy and the MEDX exercise in combination showed higher muscle strength of the lumbar extensor at all lumbar flexion angles (0°,12°,16°,24°, 36°, 48°, 60°, and 72°) than the group subjected to the MEDX exercise alone [27]. The authors of this study interpreted this result as meaning that the traction therapy reduced the pressure on the vertebral nerves caused by gravity and soft tissues and that the lumbar deep muscle strengthening exercise enhanced the muscle strength of the lumbar muscles and of the deep muscles that play a role in stabilizing the lumbar structure, thereby providing lumbar stability during diverse movements [27, 28].

The significant difference observed in the lumbar extensor after the self-traction exercise intervention in this study is thought to have resulted from the positive effects of the self-traction exercise on the stretching of the muscles and efficient blood circulation. This effectively increased the function of the muscles surrounding the vertebrae in patients with scoliosis, who tend to show low flexibility due to lowered vertebral mobility and the loss of mechanical function of the vertebrae because of weakened muscle strength and muscle endurance.

In a previous study in which torso rotation exercise and free exercise were applied to female students with idiopathic scoliosis for 12 weeks, it was reported that the muscle strength of the lumbar extensor significantly increased after the exercise intervention both in a trunk rotation group and a free exercise group. The authors of this study interpreted this result to mean that the trunk rotation exercise method, including an abdominal muscle strengthening exercise, exclusively reinforced the trunk muscles on both sides and the abdominal muscles by separating the muscle tissues, transforming the asymmetric and unbalanced muscles into more balanced muscles [29].

In a 12-week study of a combination exercise for enhancing muscle strength and flexibility in patients with scoliosis, the lumbar muscle strength significantly increased at all lumber flexion angles (0 °, 36 °, and 72 °) after the exercise. The authors of this study claimed that the improvement of lumber curvature by the exercise enabled the balanced bilateral symmetry of the muscle group surrounding the vertebrae to effectively build muscle strength through well-balanced contractions of the relevant muscle group [30].

In the comparative analysis of the changes in flexibility within the group after the intervention, no significant change was found both in the forward and backward bending of the upper body in the traction group.

In a previous study in which a combined flexibility exercise was applied to patients with scoliosis, a significant difference was observed only in the thoracic flexion angle, not in the lumbar flexion angle. This result was interpreted by the authors as an indication that the difference in the number and length of the bones between the thoracic and lumbar vertebrae led to greater changes in angle in the lumbar vertebrae than in the thoracic vertebrae. [30] This finding is consistent with the results of the present study, showing no significant difference in the forward and backward bending of the upper body in the self-traction group. No significant movement of the lumbar vertebrae was induced by the self-traction in the present study, although forward and backward bending requires greater movement of the lumbar vertebrae.

The limitations of the present study were the small sample size of 12 adults in their 20s with limited ages and the short exercise period of 4 weeks. The lack of a control group was another limitation of this study due to its single group research design. In the future, increasing the exercise period and the number of subjects is needed to more fully compare balance and pain in addition to vertebral alignment, muscle strength, and flexibility between patients with scoliosis performing self-traction exercise and scoliosis correction exercises. A control group should also be included so that more apparent differences would be revealed.

CONCLUSION

This study showed that a 4-week self-traction exercise significantly improved the vertebral alignment and the lumbar flexion muscle strength of adult subjects in their 20s with scoliosis. The comparative analysis of vertebral alignment before and after the intervention revealed a significant difference in the scoliosis angle and pelvic torsion in the self-traction exercise group. A significant difference in the muscle strength of the lumbar extensor in the self-traction exercise group was also observed after the intervention. However, no significant difference in flexibility was found, as determined by the forward and backward bending of the upper body.

These results suggest that the self-traction exercise improved the vertebral alignment and influenced the activity of the muscles surrounding the vertebrae in the subjects with scoliosis, thereby enhancing the elasticity of the muscles through the contraction and extension of the lumbar extensor. The findings of this study are expected to provide basic data for exercise programs targeting patients with scoliosis.

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