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Effects of Trunk Stabilization Exercise Using Active Vibration on Spinal Alignment in Normal Adult Females: A Randomized Controlled Trial

Background: Although studies have been conducted on muscle thickness and balance in trunk stabilization exercise and exercise using vibration props, studies on trunk stabilization exercise using active vibration for spinal alignment are still insufficient to draw a conclusion.
Objectives: To investigate the effect of trunk stabilization exercise using active vibration on the spinal alignment in adult females.
Design: A randomized controlled trial.
Methods: Twenty-six adult females were randomly assigned to the experimental group (active vibration) and 13 control groups (active non-vibrating) and exercised three times a week for 8 weeks. Each group was measured for spinal alignment before exercise and 8 weeks after exercise. Spinal alignment, trunk imbalance, pelvic tilt, and pelvic torsion were measured using a spinal alignment analyzer.
Results: Trunk imbalance was a significantly different depending on the time in the experimental group and the control group ($P<.05$). Pelvic tilt was a significant difference between the groups ($P<.05$). Also, pelvic tilt was a significantly different depending on the time in the experimental group ($P<.05$), but the control group showed no significant difference ($P>.05$). Pelvic torsion was no significant difference in both groups ($P>.05$).
Conclusion: This study demonstrates that trunk stabilization exercise using active vibration has a positive effect on the alignment of the spine.

Keywords: *Active vibration; Trunk stabilization exercise; Spinal alignment*

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INTRODUCTION

Females have weaker skeletons and muscles than men. In particular, female college students suffer from chronic fatigue due to prolonged study and frequent use of video terminals such as smartphones.[1] In addition, it is known that the incidence of conditions such as imbalance of spinal alignment is high due to bad posture with characteristics such as lack of exercise, habitual repetitive leg twisting, and preference for high-heeled shoes to meet aesthetic standards.[2]

Spinal alignment is an ideal arrangement of the skeletal system and muscles, and the center of gravity is evenly distributed to both feet, and the body center line passing from the ear to the shoulder, hip joint, knee, and ankle joints and the center of gravity line coincide.[3] Improper spinal alignment causes tension headaches, neck and shoulder muscle tension and pain, stiff arms and shoulders, chronic fatigue, and pain in the neck and lumbar discs, spinal vertebrae, and back. It also affects mental health and can lead to distraction, decreased concentration, lethargy, and irritability.[4] Exercise is reported to be effective in reducing pain, improving daily activities, increasing muscle strength, increasing range of motion, and increasing balance ability.[5]

Trunk stabilization exercise refers to treatment so that the biceps and abdominal muscles are activated at the same time to stabilize the trunk during the start or movement of the arm or leg.[6] By repeatedly stretching and strengthening the trunk muscles, the stability and movement of the spine is maximized.[7] As a result of performing trunk stabilization exercise with adolescent patients with lateral flexion, it was more effective in correcting spinal rotation and reducing pain than traditional treatment alone.[8] For patients with incomplete spinal injury, the results of exercise to strengthen the stability of the trunk for 12 weeks resulted in a neutral spinal alignment and stabilization of the trunk muscles.[9] In addition, it was reported that an 8 week trunk stabilization exercise program improved the spinal alignment of college students.[10] Recently, studies on trunk stabilization motion using vibration props have been conducted.

XCO and flexi-bar trunk stabilization exercise, a prop that generates vibration through active movement, is said to be effective for trunk muscle thickness, balance, erector spinae muscle activation, gait, lower back dysfunction, and low back pain.[11-16] Smovey is an active vibration exercise, and it has beads that generate vibration when swinging, strengthening the core muscles and stabilizing the spine, and controlling the intensity without worrying about injury.[17] The grip strength, gait ability and quality of life of breast cancer patients were improved by performing active vibration exercise using Smovey.[18] For middle-aged females, it was reported that it had positive effects on endurance, balance ability, capillary length, and body surface temperature.[19]

Previous studies still lack basic data on the application of active vibration exercise to determine the alignment of the spine. Also, until now, no research on spinal alignment using Smovey has been conducted. Therefore, this study aims to find out the effects of trunk stabilization exercise using active vibration on spinal alignment in adult females and to suggest future clinical use.

SUBJECTS AND METHODS

Subjects

This study was conducted with adult females from N University located in G City. The experiment group (active vibration) had 13 subjects, and the control group (active non-vibration group) had 13 subjects, for a total of 26 subjects randomly assigned using random numbers, and they exercised for 8 weeks. Before participating in the study, all subjects voluntarily filled out a consent form and participated after being fully informed of the purpose and method of the study (Table 1).

Study Procedures

The researcher made random numbers in opaque boxes were divided randomly after that to select subjects. The experimental group and the control group performed body stabilization exercise using active vibration three times a week for a total of 8 weeks. Five minutes of warm-up exercise and main exercise were divided into 40 minutes for 1-4 weeks, 50 minutes for 5-8 weeks, and 5 minutes for finishing exercise.[20] All exercise was conducted under the supervision and direction of the researcher. Two groups were evaluated before exercise and after 8 weeks of exercise to determine the effects of intergroup exercise intervention.

Outcome Measures

Spinal alignment measurement

For measurement of spinal alignment, Formetric 4D (Diers, Inc., Germany), a three-dimensional image spinal alignment analyzer, was used to measure trunk imbalance, pelvic tilt, and pelvic torsion in the spine. This instrument is a light-optical scanning method based on Video-Raster-Stereography (VRS). The instrument's halogen lamp system is projected onto the back, allowing the spine to be deformed from the contours of the back surface. The software was used DICAM basic. For the photographing, the subjects' tops were removed and the sacrum point was shown, and their underwear was lowered so that the rear tailbone was visible. At this time, the subjects were allowed to stand with both legs stretched and the whole body relaxed, maintaining a comfortable posture. This measuring instrument has proven to be very reliable and accurate when compared to radiation equipment.[21,22]

Table 1. Characteristics of subjects

(Mean ± SD)

	Experimental group (n=13)	Control group (n=13)
Age (years)	20.77 ± .83	20.77 ± .83
Height (cm)	160.75 ± 4.98	160.62 ± 3.54
Weight (kg)	57.65 ± 12.36	56.95 ± 8.29

Interventions

The experimental group in this study used Smovey (Smovey MED, Smovey, Switzerland) as an active vibration tool. It is 27.5 cm wide and 20 cm long, weighs about 1 kg, and is an oval tube-shaped plastic material that generates 50 ㎐ of vibration when three iron balls swing (Figure 1). The control group tool was manufactured with the same material, size, and weight while removing the beads to prevent vibration (Figure 2).

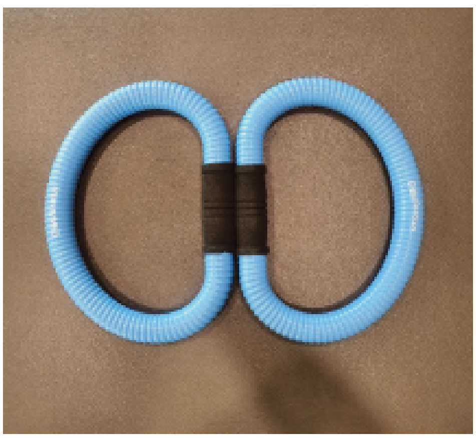

Figure 1. Smovey (Smovey MED, Smovey, Switzerland)

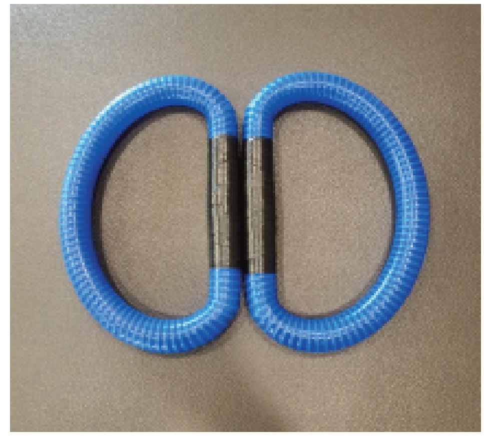

Figure 2. Non-vibration swing equipment

Experiment group

There are four movements, and the exercise was performed left and right. For the first 1-4 weeks, there were five sets with 50 seconds for each movement, and five sets with 65 seconds for each movement during 5-8 weeks. During this exercise, the subjects took a break for 30 seconds after one set.[23]

The movement motion is shown in Figure 3.

A. On the same side of the limb, the shoulder is flexion-adduction, the leg is fixed, and the other limb is extended with shoulder abduction,

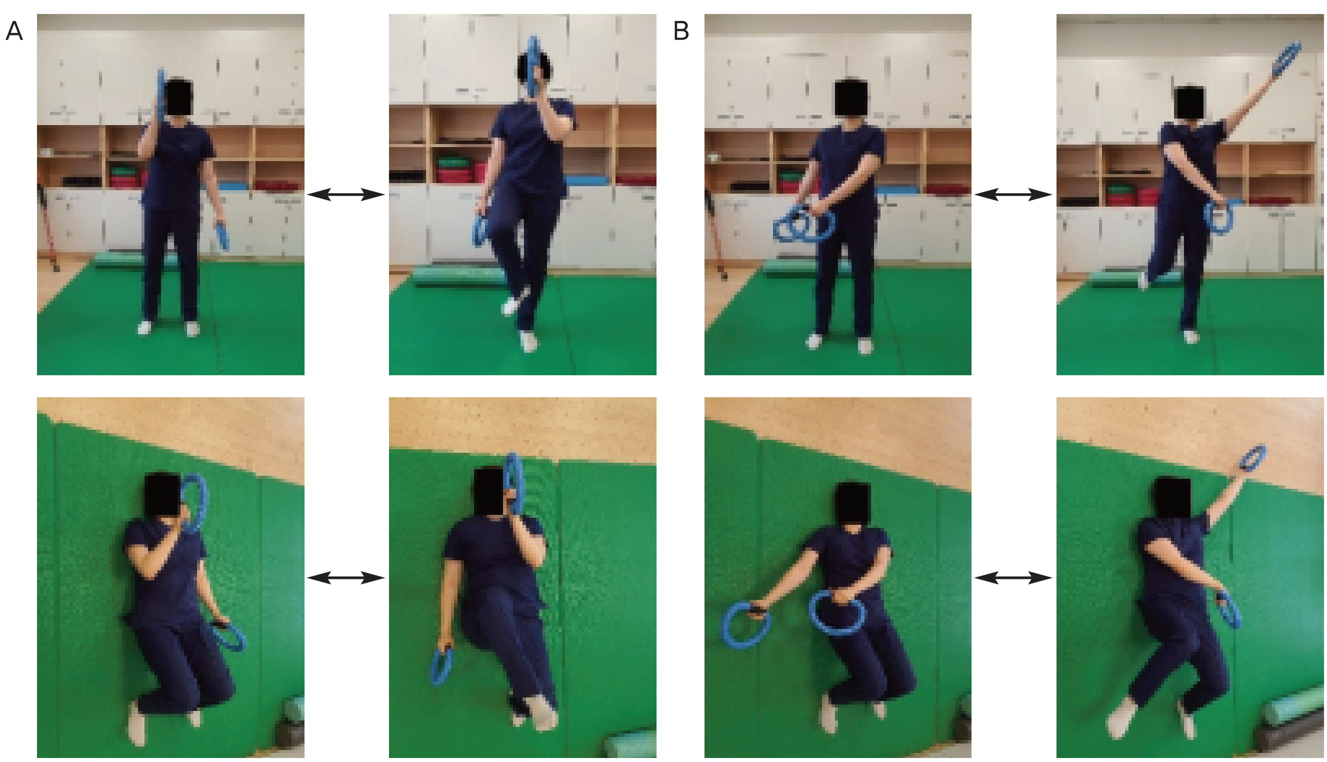

Figure 3. Smovey exercise

and the leg is moved in the hip flexion-adduction (Figure 3).

B. On the same side of the limb, the shoulder is flexion-abduction, the leg is fixed, and the other limb is extended with shoulder adduction, and the leg is moved in the hip extension-abduction (Figure 3).

Control group

It was applied in the same way as the experimental group.

Data and Statistical Analysis

The data processing method of this study was plotted by calculating the mean and standard deviation of the measured items using the SPSS 22.0 statistical program. A correspondence sample t-test was used to compare the vertebral alignment before and after exercise in each group, and an independent sample t-test was used for comparison between each group. The statistical significance level for all variables was set to α=.05.

RESULTS

Change in spinal alignment

As for change of spinal alignment, the trunk imbalance was significantly different according to the period in both the experimental group and the control group ($P<.05$). The pelvic tilt was significantly different in the experimental group according to the time ($P<.05$). There was no significant difference in the control group ($P>.05$). The pelvic torsion was no significant difference in both the experimental group and the control group ($P>.05$). There was a significant difference in pelvic tilt between groups ($P<.05$) (Table 2).

DISCUSSION

Spinal alignment is in the most stable state when the spine is maintained in an S-shaped curve and is straight, and a balanced posture without biasing in either direction gives the least strain to the spine.[24] If the spine and the pelvis are not properly aligned due to the collapse of this stable state, the spine is tilted in one direction, resulting in an objective curve of the human body, resulting in a difference in leg length and damage to the soft tissue around the pelvis.[25] Among the studies on the alignment of the spine, the study of motion using active vibration is insufficient. Therefore, this study was conducted to find out how trunk stabilization exercise using active vibration for 8 weeks affects the alignment of the spine.

As a result, for trunk imbalance, significant differences were found in both the experimental group and the control group according to the time period. It was

Table 2. Comparison between groups for duration of application of spinal alignment

(Mean ± SD)

		Pre-test	Post-test	t	P
Trunk imbalance	Experimental group	16.08 ± 11.47	10.31 ± 8.78	2.342	.037*
	Control group	15.92 ± 11.19	7.54 ± 5.11	2.195	.049*
	t	.035	.983		
	P	.973	.335		
Pelvic tilt	Experimental group	6.92 ± 5.66	1.77 ± 2.28	3.127	.009*
	Control group	6.00 ± 4.42	3.92 ± 2.56	1.897	.082
	t	.463	-2.264		
	P	.647	.033*		
Pelvic torsion	Experimental group	1.92 ± 1.44	1.62 ± 1.39	.671	.515
	Control group	3.15 ± 1.99	3.08 ± 2.18	.130	.899
	t	-1.804	-2.041		
	P	.084	.052		

*$P<.05$

reported that repetitive unilateral movements and fixed posture affect the trunk muscles, causing changes in the shape of the spine and musculoskeletal pain.[26] The trunk stabilization exercise in this study has the characteristic that limbs move left and right diagonally to each other. This is not a unilateral motion, but a bilateral motion, and the trunk muscles contract and relax in both directions. The subjects did not exercise usually, so it is judged that bilateral exercise was helpful in the imbalance of the trunk muscles. Also, it is thought that trunk imbalance was affected by continuous contractions of the trunk muscles to prevent the trunk from rotating. Among previous studies, After bilateral exercise, the trunk appeared in a more balanced shape and the muscles were developed.[27] In addition, 12 weeks of abdominal muscle exercise had a positive effect on the trunk imbalance angle.[28] Of the two groups, the experimental group was considered to have a greater effect on trunk imbalance due to the higher contraction force of the trunk muscles than the control group without vibration due to the resistance of vibration generated by active vibration when performing the swing movement of shoulder bending and spreading. As a result of comparing the trunk exercise using active vibration and the trunk exercise without vibration in healthy adult males and females, it was found that the thickness of the trunk muscles was further improved in the trunk exercise group using active vibration.[11]

In the pelvic tilt, there were significant differences according to the period in the experimental group, and there were significant differences between groups. Pelvic tilt is divided into left and right lateral tilt, anterior tilt, and posterior tilt, and the movement of the left and right lateral tilt is said to be caused by the contraction of the quadratus lumborum on the side where the pelvis is raised, and the contraction of the gluteus medius on the other side.[29] It was reported that the anterior tilt movement was caused by contraction of the extensor muscles of the lower back and the flexor muscles of the hip joint, and the movement of the posterior tilt occurred by contraction of the rectus abdominis and the extensor muscles of the hip joint.[30] The trunk stabilization exercise of this study is an exercise that continuously moves with the bending and extension motions of the opposite hip joint while one leg is supported. If there is a difference in the pelvic tilt, shaking occurs. The experimental group receives a shake and resistance by continuous vibration. In order for the trunk to remain unshakable and to stand on one leg continuously, the trunk and gluteus medius must be contracted continuously, and At the opposite hip joint, repetitive contraction and relaxation of the flexor and extensor muscles occur. It is thought that stimulation of vibration and motor movements increased pelvic mobility and affected pelvic tilt due to contraction and relaxation of muscles. In previous studies, in order to maintain a stable posture in the training group with amplitude and rhythmic stimulation, it affected not only the legs but also the pelvic, which affected the pelvic tilt.[31] Also, it was reported that the increase of the hip joint extensor muscle strength increased the stability of the hip joint, resulting in a decrease in the pelvic tilt.[32] 8 weeks of vibrational exercise had a positive effect on pelvic tilt compared to the group without vibration.[33] Also, this study was supported by the fact that the vibration stimulation of the trunk for 12 weeks improved pelvic tilt.[34]

As for pelvic torsion, there was no significant difference in both the experimental group and the control group. Pelvic torsion refers to the rotation of the pelvis left and right, and the closer to 0°, the better the alignment. The imbalance of the pelvis and trunk are closely related to each other.[35,36] In addition, stabilization of the pelvis takes place along with stabilization of the trunk, and stabilization of the trunk takes a long time.[37] In the results of this study, during the 8 week exercise period, there was no significant difference between the timing and the group, but it was confirmed that the angle decreased. In addition, the angle of the active vibration group was reduced more than that of the group without vibration. It is thought that if a longer time than 8 weeks is applied, trunk stabilization exercise using active vibration will have a positive effect on pelvic torsion. As a result of performing 8 weeks of trunk exercise for male and female college students, it was consistent with this study, saying that more than 8 weeks of exercise would have an effect on pelvic torsion.[38]

From the above research results, among the vertebral alignment, great effects were found on trunk imbalance and pelvic tilt. It was confirmed that trunk stabilization exercise using active vibration had a positive effect on the spinal alignment of adult females. The limitation of this study is that it is difficult to generalize as the study was conducted on adult female, not patients. Therefore, in future studies, it is considered that research should be continued not only on subjects with musculoskeletal problems but also on various subjects with problems related to the nervous system.

CONCLUSION

The purpose of this study was to investigate the effects of trunk stabilization exercise using active vibration on spinal alignment in adult females. As a result of the experiment, significant differences were found in trunk imbalance and pelvic tilt in the change of spinal alignment. As a result, it was confirmed that trunk stabilization exercise using active vibration had a positive effect on the alignment of the spine. Therefore, it is thought that trunk stabilization exercise using active vibration can be provided as a clinical intervention method for spinal alignment.

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