



Original Article

The effect of flexi-bar exercise with vibration on trunk muscle thickness and balance in university students in their twenties

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Abstract. [Purpose] The purpose of this research was to determine the effect of Flexi-Bar exercise with vibration on trunk muscle thickness and balance in university students in their twenties. [Subjects and Methods] This research evaluated 26 university students in their twenties, equally and randomly divided into two groups. Both the experimental and control groups used an ordinary pole for exercise. In addition, the experimental group exercised by using a Flexi-Bar. Ultrasonic imaging was used to measure the changes in trunk muscle thickness. A balance measuring equipment was used to measure balance ability. [Results] The thickness of the transversus abdominis and the multifidus muscles in the experimental group increased, and the experimental group showed increased thickness in the transversus abdominis muscle compared to the control group. After 6 months of exercise, there was an improvement in the blind Romberg test and center of pressure moving distance with one-leg standing. [Conclusion] These results indicate that the Flexi-Bar exercise is effective in increasing trunk muscle thickness and improving balance.

Key words: Flex-bar exercise, Trunk muscles, Balance

(This article was submitted Dec. 14, 2015, and was accepted Jan. 8, 2016)

INTRODUCTION

Spine stabilization is demonstrated by the coordination of trunk muscle activities¹⁾. During spine stabilizing exercise, multiple muscles must be activated simultaneously²⁾. Trunk muscles are classified as major or minor depending on their role. Major muscles, including the rectus abdominis, the external oblique, and the erector spine are superficially located, connect the trunk and pelvis, and provide control for the ability to bear weight applied to the trunk³⁾. Minor muscles, including the multifidus, interspinales, intertransversarii, transversus abdominis, and internal oblique, are located in the deep plane, and ensure the dynamic stability of the spine. The minor muscles are particularly effective for controlling the stiffness of spinal segments and maintaining spinal posture⁴⁾.

There are several trunk stabilizing exercise methods, such as the Swiss ball exercise on uneven ground, core exercises, curl-up exercises, and pilates⁵⁻⁸⁾. Among equipment that accelerates trunk stabilization using vibration, recently, the Flexi-Bar has been used in hospitals and fitness centers⁹⁾. The Flexi-Bar is weighted and flexible and is designed for use at small amplitudes of 5 Hz, transmitting a vibration when held by the user while maintaining its physical shape⁹⁾. The Flexi-Bar is safe as the vibratory stimulation is of small amplitude and can be used without special training¹⁰⁾. The vibration speed and amplitude generated by the Flexi-Bar can be modulated by active vibration stimulation generated by the user and can be

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performed in various positions safely and conveniently^{10, 11}).

Trunk muscular strength is essential to maintain to facilitate changes in stance and to keep one's balance¹²). The simplest way to evaluate muscular strength is through measurement¹³). The magnitude of strength can be measured directly through muscle contraction. By measuring cross-sectional area and muscular thickness via ultrasonography, we can determine increases in muscular strength^{12, 13}). A few studies have measured muscular thickness and trunk muscle strength after the Flexi-Bar exercise; however, the research on balance is lacking. The purpose of this study was to determine the effect of Flexi-Bar exercise with vibration on trunk muscle thickness and balance in university students in their twenties.

SUBJECTS AND METHODS

This study evaluated 26 university students in their twenties. After acknowledging, understanding, and agreeing to participate, 13 subjects were randomly assigned to the control group, and 13 who performed Flexi-Bar exercises were assigned to the experimental group. Those with an orthopedic disease of the extremities, history of shoulder surgery or treatment, and who regularly exercised with weights were excluded. All participants provided informed consent before the experiment. The ethics committee of Nambu University approved this study. The general characteristics of the participants are presented in Table 1. The mean age, height, and weight were 20.4±1.1 y, 167.2±7.1 cm, and 63.7±14.9 kg in the experimental group, and 20.8±1.1 y, 168.4±7.2 cm, and 69.0±14.9 kg in the control group, respectively.

The experimental and control groups used an ordinary pole for exercise. In addition, the experimental group exercised with a Flexi-Bar (Togu, Germany). The Flexi-Bar vibrates 270 times/min and can be used for shoulder joint and whole-body exercise. Voluntary transmission of vibration to the arm causes concurrent contraction of the shoulder and trunk muscles and improves muscular strength, stability, and proprioceptive sense around the shoulder. The Flexi-Bar is 153 cm long, weighs 710 g, and is 9.5 mm thick. Exercise intensity can be modulated by changing the weight and thickness of the Flexi-Bar. The Flexi-Bar exercise comprises eight programs, including Butterfly Front, Butterfly Up, Butterfly Down, Right Left, Spine Alignment, Shoulder and Upper back, Abdominals, and Torso Musculature. The Flexi-Bar exercise was performed for 30 minutes, thrice a week for 6 months.

Ultrasonic imaging (MySono U6, Samsung Medison, Korea) was used to measure the changes in thickness of the trunk muscles. The B-scan mode was used for imaging. The transversus abdominis, external oblique, internal oblique, and multifidus muscles were measured with the subject horizontal. A balance measuring instruments (RM Ingénierie, Rodez, France) were used to measure balance ability. These comprised a platform that can sense the moving distance of the center of pressure (COP), a computer analysis program, and a monitor. The Romberg test was used to measure static balance. The COP moving distance was measured as follows: the subject stood on the platform with legs spread about 30° apart and with their eyes fixed ahead; they balanced for 1 min, and maintained minimal movement. The subject was required to keep their eyes open and fixed on a point on the monitor while maintaining a stance. The subject was then required to maintain the stance with their eyes closed. The gross area of stability limits was measured to determine dynamic balance. The subject was required to move from the stance in eight directions shown on the monitor: front, back, left, right, and diagonally, with a maximized COP.

The data were analyzed using SPSS 12.0 (SPSS, Chicago, IL, USA). Descriptive statistics were calculated using the general characteristics of the participants. The paired t-test was used to compare in-group data before and after the intervention. The independent t-test was used to compare the results of changes in thickness of the trunk muscles, and balance before and after the intervention between the groups. The significance level was set at $\alpha=0.05$.

RESULTS

Table 2 shows changes in trunk muscle thickness and balance. The transversus abdominis and multifidus muscles in the experimental group showed increased thickness over time ($p<0.05$). The experimental group showed a greater increase in thickness in the transversus abdominis compared to the control group ($p<0.05$) (Table 3). After 6 months of exercise, there was an improvement in the blind Romberg test and COP moving distance with one-leg standing.

Table 1. General characteristics of the participants

	Experimental group (n=13)	Control group (n=13)
Gender (male/female)	7/6	6/7
Age (years)	20.4±1.1	20.8±1.1
Weight (kg)	63.7±14.9	69.0±14.9
Height (cm)	167.2±7.1	168.4±7.2

DISCUSSION

The purpose of this research was to determine the effect of the Flexi-Bar exercise with vibration on trunk muscle thickness and balance in university students in their twenties. After 6 months of exercise with the Flexi-Bar with vibration, the thickness of the transversus abdominis clearly increased. Comparison of the values before and after 6 months of exercise showed a significant increase in muscular thickness relative to the control group. After 6 months of exercise, there was a greater increase in the multifidus thickness compared to before the exercise. However, there were no differences in the internal oblique and external oblique muscles over time, and there were no differences between the experimental and control groups. Stevens et al.¹⁴⁾ reported that the activity of the trunk muscles increased markedly as the external weight on the limbs increased. In their study, they examined 14 male subjects to determine pressure tolerance and spinal stability of the 4th and 5th lumbar vertebrae. Stevens et al.¹⁴⁾ used a vibrating instrument, with a pressure tolerance of 1,670N of horizontal vibration measured at low amplitude and a tolerance of 4,328N of vertical vibration measured at high amplitude. Vibrations transferred by the Flexi-Bar pressed against the spine improved muscular thickness¹⁵⁾. In contrast, Chung et al.¹⁶⁾ reported different results for the effect of the Flexi-Bar exercise on the activation of trunk muscles. The Flexi-Bar exercise showed greater external weight effect compared to the use of a non-vibrating bar, with clear differences in the activation of the internal oblique and external oblique muscles. The oblique muscles affect trunk flexion, rotation, and lateral flexion. The one-hand use of the Flexi-Bar stimulated the oblique muscles, which was not observed in this study. It is possible that stimulation of the diagonally oriented oblique muscles could not be accomplished because the vibration was applied vertically and horizontally using both hands in all stances.

Balance ability was determined using the Romberg test with eyes opened and closed, COP moving distance with one-leg standing and gross area of the COP moving distance for stability limits. In the Romberg test, a clear decrease in COP moving distance was shown, and 6 months of exercise resulted in greater improvement in one-leg standing compared to that observed before exercise. In comparing results before and after 6 months of exercise, no differences were shown between the experimental and control groups. The results of the Romberg test differed for eyes open and closed as the proprioceptive sense with eyes closed is mobilized more than that with eyes open. Proprioceptive sense conveys information on a position, movement,

Table 2. Comparison of the results of trunk muscle thickness and balance between the experimental and control groups

	Group	Pre	Post	D-Value
Transversus abdominis muscle (mm)	Experimental group	3.9±1.1	6.3±2.0*	2.4±1.6#
	Control group	4.0±1.7	4.9±1.3	0.9±1.6
Internal oblique muscle (mm)	Experimental group	9.6±2.5	9.8±2.6	0.1±3.3
	Control group	10.0±2.2	9.8±2.2	0.1±2.3
External oblique muscle (mm)	Experimental group	5.9±2.1	6.7±1.9	0.8±2.8
	Control group	7.2±2.4	7.7±2.1	0.4±3.3
Multifidus muscle (mm)	Experimental group	7.8±1.5	8.6±1.9*	0.8±2.8
	Control group	7.3±1.7	8.1±1.8*	0.4±3.3

*p<0.05: paired t-test

#p<0.05: independent t-test

D-value: Difference value

Table 3. Comparison of the results of balance between the experimental and control groups

	Group	Pre	Post	D-Value
COP moving distance change in Romberg test with eyes open (cm)	Experimental group	11.3±2.7	11.1±5.6	0.2±2.1
	Control group	11.8±6.0	11.2±1.1	0.6±3.2
COP moving distance change in Romberg test with eyes closed (cm)	Experimental group	13.0±2.6	11.1±1.7*	1.7±1.6
	Control group	13.7±7.8	12.2±6.8	1.4±3.9
COP moving distance change in one-leg standing (cm)	Experimental group	32.3±8.6	27.9±8.7*	4.4±7.4
	Control group	29.0±12.9	27.9±10.9	1.1±4.9
Gross area change of stability limits (cm)	Experimental group	57.5±22.6	69.3±26.7	11.8±29.1
	Control group	48.7±23.2	53.8±22.0	5.1±9.7

*p<0.05: paired t-test

#p<0.05: independent t-test

D-value: Difference value

and joint vibration to the central nervous system; therefore, vibration conveyed from the Flexi-Bar to the foot could have improved proprioceptive sense. Mileva et al.⁹⁾ reported that Flexi-Bar exercise with 5-Hz vibration from the hand to the arm muscles that continued to the trunk and legs, and influenced the one-leg squatting position. Abercromby et al.¹⁷⁾ reported that when vibration is transmitted from the trunk with the subject standing on a whole body vibration platform, continuous stimulation in a standing position depends on passive mechanisms that weaken the amplitude of the continuous vibration level and adversely affect energy storage in the body. This also adversely affects vestibular sense and sight without affecting balance, while vibration uses active mechanisms to assist in balance^{17, 18)}. Simultaneous contraction of lumbar muscles reportedly improved stance control in one-leg standing¹⁸⁾. This research showed that increased thickness of the multifidus and transversus abdominis muscles improved one-leg standing. Stability of dynamic balance can be determined by calculating the area of the range of body movements in the directions shown by arrows on the monitor of the balance measuring instrument, but the change did not correspond to time and group. This may be because the subjects were university students in their twenties with no lower extremity musculoskeletal disorders, in whom it was difficult to measure dynamic balance. Moreover, because the subjects moved in the direction of arrows shown on the monitor, measurements depended on sight alone, rather than the combination of sight and vestibular and proprioceptive senses^{18, 19)}. The movement was not dependent on normal vision in this research; sight is too sensitive to be affected by other sensory systems, and measurements dependent on visual stimulation could not affect dynamic balance¹⁹⁾. A limitation of this research is that the number of subjects was too small to normalize the results. In addition, the Flexi-Bar exercise uses actively induced vibration, but the point at which a change of amplitude could affect muscular thickness could not be determined since not all subjects could achieve the same changes in amplitude. Furthermore, the muscular thickness measured by ultrasonography was measured in the resting state, and not in the contracted state. Measurement of muscular thickness in the contracted state could have evaluated improvements in muscular strength with greater sensitivity. Clinical research is needed for patients with abdominal pain and trunk instability.

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