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Effects of Active Vibration Exercise Using a Flexi-Bar on the Activity of Scapular Stabilizing Muscles: A Randomized Controlled Trial

Background: It has been argued that changes in muscle activity in the upper trapezius and serratus anterior may or may not cause shoulder joint pain and dysfunction.
Objective: To investigate the effects of active vibration exercise on muscle activity regarding scapular stabilization using a flexi-bar.
Design: A randomized controlled trial.
Methods: A total of 24 subjects were randomly assigned to a flexi-bar group with active vibration and general stick group with non-active vibration. Both groups performed the same four action programs for 6 weeks, three times a week for 30 minutes at a time. The upper trapezius muscle, middle trapezius muscle, lower trapezius muscle and serratus anterior muscle of the dominant side was measured by electromyography before and after the 6 weeks of exercise. The independent t-test and paired t-test were used to analyze data.
Results: There was a significant difference between groups in upper trapezius muscle and serratus anterior muscle activity after exercise (P<.05). Also, there was a significant difference in upper trapezius muscle and serratus anterior muscle activity before and after exercise in the flexi-bar group (P<.05).
Conclusion: This study demonstrates that active vibration exercise using a flexi-Bar contribute to reduce the activity of the upper trapezius muscle and promote the activity of the serratus anterior muscle.

Keywords: *Scapular stabilizing; Upper trapezius muscle; Serratus anterior muscle; Electromyography; Flexi-bar*

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INTRODUCTION

The scapular stabilizing muscles are typically the upper trapezius muscle and the serratus anterior muscle, which couple forces to provide stability to the scapular.[1-3] The serratus anterior muscle produces scapular upward rotation during movement of the upper arm and provides dynamic stability by properly maintaining and controlling the stability and position of the scapular.[4,5]

In the case of the trapezius muscle, the upper trapezius muscle, middle trapezius muscle, and lower trapezius muscle are divided, and when the trapezius muscle function decreases the stability of the scapular, the head part of the humerus cannot be placed in the center of the concave glenohumeral joint.[6] It is also known that dysfunction and pain in the shoulder joint are induced when the activity of the upper trapezius muscle increases and activity of the serratus anterior muscle decreases.[4] The lower trapezius muscle also reduces scapular downward rotation when the upper arm is lowered, which reduces scapular stability so in order to recover the function of the normal glenohumeral joint, the function of the serratus anterior muscle and upper trapezius muscle should be made normal.[1] Electromyography (EMG) studies of subjects with dysfunction in the glenohumeral joints showed that the activity of the serratus anterior muscle and lower trapezius muscle decreased in several exercise positions for the side-lying

position, prone position, standing, and push-up.[1,4] Selective exercise, angle, and position are necessary because of the excessive activity of the upper trapezius muscle.

Various scapular stabilization exercise methods are used to solve these problems. These exercises include wall push exercises, isometric exercises, push-up plus exercises, and flexi-bar exercises.[4,7-9] Among the various exercise methods, active vibration exercise using a flexi-bar can activate muscle spindles and stimulate the senses through vibration stimulation, which can help strengthen the muscles that provide proprioception and stability to posture.[10] Active vibration stimulation can cause simultaneous co-contraction of muscles, which can improve neuromuscular control ability and strength so it can suppress abnormal muscle tension, so it can be applied to muscle control imbalance subjects.[11]

The flexi-bar generates about 5 Hz of active vibration, which is suitable for functional proprioception training through arm pulling and pushing so it can effectively generate vibrations without other compensatory movements.[12] In addition, the flexi-bar is effective in increasing range of motion, deep muscle stimulation and muscle strength, and pain relief by using the upper body, legs, and torso simultaneously to create active vibration.[13]

Previous studies comparing trunk muscle activity between a flexi-bar group and general bar group have shown that flexi-bar exercise is useful for activating torso muscles.[14] However, previous studies have focused on trunk muscles and immediate effects. Therefore, the purpose of this study is to compare the activation of scapular stabilization muscles after 6 weeks of active vibration using the flexi-bar and non-vibration general bar exercise and suggest an effective method.

SUBJECTS AND METHODS

Subjects

In this study, a total of 24 university students from N University in G city were randomly assigned to two groups of 12 students using random numbers. The criteria for the selection were healthy adults and volunteers who participated in the study. Exclusion criteria were those who have neurological or musculoskeletal disorders affecting exercise, those who exercise with regular strength in the shoulder area, and those who have pain. The general features of the subjects are shown in Table 1. The Ethics Committee and Institutional Review Board of N University approved this study (IRB 1041478-2018-HR-024).

Table 1. Characteristics of subjects.

General characteristic	FBG (n=12)	GBG (n=12)
Age (year)	20.83 ± 1.11	20.42 ± 1.16
Height (cm)	168.58 ± .07	167.00 ± .07
Weight (kg)	63.91 ± 5.12	61.35 ± 4.28
Gender (Male/Female)	6/6	6/6
Dominant (Left/Right)	4/8	0/12

Mean ± SD, FBG: Flexi-Bar Group, GSG: General Stick Group

Outcome Measures

Exercise tool

The flexi-bar (Flexi-bar Inc., Germany) used by the flexi-bar group in this study is 1,530 mm in length, 9 mm in thickness, 650 g in weight, and causes 270 vibrations per minute. The bar used by the general bar group was specially manufactured with the same length and weight as the flexi-bar.

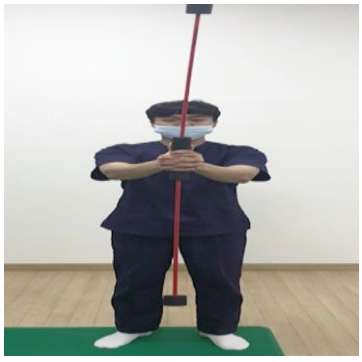
Exercise program

Table 2 shows the motions and schedule of the exercise program. They used different tools with the same exercise program. The exercise program was conducted once every 30 minutes, three times a week for a total of six weeks. Participants perform a whole-body stretching before exercise. Only the bars are different and the method of exercise is the same. Exercise 1 holds the bar horizontally, push and pull toward the front. Exercise 2 holds the bar vertically, push and pull toward the side. Exercise 3 holds the bar horizontally, push and pull toward the overhead. Exercise 4 holds the bar vertically, push and pull toward the front. Participants perform a whole-body stretching after exercise.

Electromyography

In this study, surface EMG (BTS300, BTS company, Italy) was used to investigate changes in muscle activity before and after intervention in the flexi-bar and general bar groups. Surface EMG electrodes were attached to the upper trapezius muscle, middle trapezius muscle, lower trapezius muscle, and serratus anterior muscle. The attachment position of the upper trapezius muscle was the posterior portion of the centerline connecting the C7 and the acromioclavicular joint. The middle trapezius muscle was attached between T3 spinous process and scapula

Table 2. Exercise program.

Step	Program		Time (min.)
Warm up	Whole body stretching		5
Exercise	Anterior view (FBG)	Side view (GBG)	
1			5
2			Left: 2.5 Right: 2.5
3			5
4			5
Cool down	Whole body stretching		5

FBG: Flexi-Bar Group, GSG: General Stick Group

spine. The lower trapezius muscle was attached diagonally at a position of about 1.5 cm from the T6 spinous process. The serratus anterior muscle was attached to the posterior portion of the axillary centerline at the five and sixth rib height.[15-17] The distance between the electrodes was 2 cm, and the attachment site was wiped clean with alcohol cotton before attachment.

EMG signal processing methods

The sampling rate of the surface EMG signal was set to 1,000 Hz. Each group's according to the measured position of previous studies so EMG was measured for 5 seconds in the posture of exercise 1 and measured three times.[7] A break of at least 1 minute was given between measurements. The data collected for 3 seconds after excluding the initial 1 second and last 1 second were quantified by root mean square. Muscle maxima were measured based on the manual muscle test method for each muscle. The collected EMG signals were expressed as the maximum voluntary isotropic contractile percentage.

Data and Statistical Analysis

All the statistical analyses were performed using IBM SPSS Statistics ver. 21.0 (SPSS Inc., Chicago, IL, USA). The Shapiro-Wilk test was used for the normality test. An independent t-test was used to examine differences between groups, and a paired t-test was used to determine the difference between before and after exercise in each group. Statistical significance was set at α=.05.

RESULTS

Comparison of EMG between flexi-bar group and general bar group

A comparison of EMG between the flexi-bar group and general bar group is shown in Table 3. There was a significant difference in the flexi-bar group upper trapezius muscle and serratus anterior muscle group after exercise (P<.05). There were significant differences between the groups in the upper trapezius muscle and the serratus anterior muscle after exercise by the flexi-bar group and the general bar group (P<.05).

Table 3. Comparison of EMG between flexi-bar group and general bar group. (unit: %MVIC)

Muscle		Pre	Post	t	*P*
Upper Trapezius	FBG	56.82 ± 6.56	48.80 ± 8.80	4.123	.002*
	GBG	53.24 ± 6.53	56.83 ± 8.46	-.996	.341
	t	1.340	-2.279		
	P	.194	.033*		
Middle Trapezius	FBG	49.50 ± 8.76	50.65 ± 6.29	-.426	.678
	GBG	47.29 ± 8.84	46.03 ± 4.52	.658	.524
	t	.617	2.066		
	P	.544	.051		
Lower Trapezius	FBG	46.02 ± 8.65	45.91 ± 13.59	.023	.982
	GBG	47.29 ± 8.84	43.86 ± 13.71	.870	.403
	t	-.508	.349		
	P	.616	.731		
Serratus Anterior	FBG	42.02 ± 6.68	46.00 ± 6.74	-3.109	.010*
	GBG	40.73 ± 5.00	39.03 ± 8.59	.652	.528
	t	.535	2.209		
	P	.598	.038*		

*P< .05. Mean ± SD, FBG: Flexi-Bar Group, GSG: General Stick Group

DISCUSSION

The purpose of this study was to compare a flexi-bar and general bar to investigate the effects of 6 weeks of active vibration exercise with a flexi-bar on muscle activity regarding scapular stabilization. The results of this study showed that the flexi-bar group had a significant difference in the decrease in muscle activity of the upper trapezius muscle and increase in muscle activity in the serratus anterior muscle after exercise.

Exercise is effective in function recovery and improving muscle imbalance.[18] There is a way to increase the effectiveness of exercise by combining vibration during exercise. Vibration stimulates sensory nerve fibers in the muscle spindle of muscles to activate muscles connected by alpha motor neurons.[19] In addition, vibrations affect not only the main muscles, but also the surrounding muscles.[20]

Vibration stimulation during flexi-bar exercise causes muscle contraction at low frequencies of about 5 Hz.[21,22] Previous studies have reported that flexi-bar-like body-blade exercise has a significant effect on the activation of the upper trapezius muscle, lower trapezius muscle, and serratus anterior muscles.[23] In the present study, the flexi-bar group showed decreased activity of the upper trapezius muscle and increased serratus anterior muscles activity. This study seems to differ from previous studies in the measurement of muscle activity behavior. In the previous study, muscle activity according to the shoulder 90° flexion and abduction was measured. However, this study measured muscle activity by flexion of the shoulder 90° according to the flexi-bar's push and pull principle. The activity of the upper trapezius muscle decreased due to the increase in activity of the serratus anterior muscles.

In the open chain exercise, serratus anterior muscle activity increased at 110° of shoulder flexion, but exercise was effective at 90° shoulder flexion to increase the activity of the serratus anterior muscle while lowering the activity of the upper trapezius muscle.[24] Among the various postures during flexi-bar exercise, the highest activity of the serratus anterior muscles was when the shoulder was flexed at 90° and the tool was held horizontally.[7] In a six-week study with a body-blade, which is like a flexi-bar, EMG measured with shoulder joint flexion to 90° position while wrist joint touching the bar.[25] The activity of the upper trapezius muscle decreased and the activity of the serratus anterior muscle increased.[25] In this study, the same results as in previous studies were shown. As a result, active vibration using a flexi-bar is considered to be one of the effective methods for stabilizing the scapula.

This study has some limitations. The number of subjects was small and the study was conducted on normal adults rather than patients. Further research is needed to address these limitations.

CONCLUSION

In this study, active vibration exercise using a flexi-bar lowered the activity of the upper trapezius muscle, which is required for stabilization of the scapula, and improved the activity of the serratus anterior muscles. The flexi-bar is thought to be a good tool for scapula stabilization.

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