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The Effects of Shoulder Stabilization Exercise and Shoulder Isometric Resistance Exercise on Shoulder Stability and Hand Function

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Abstract. [Purpose] The purpose of this study was to compare the effects of shoulder stabilization exercise and shoulder isometric resistance exercise on maximum voluntary isometric contraction (MVIC) rate of change of shoulder stabilization muscles and hand function. [Method] The subjects of this study were nineteen healthy adults who had no problems with their musculoskeletal system. Group I performed shoulder stabilization exercise with a ball for 30 minutes. Group II performed shoulder isometric resistance exercise without a ball for 30 minutes. Electromyography recorded the MVIC rate of change of the upper trapezius, lower trapezius and serratus anterior in a manual muscle testing position after each exercise. All subjects were assessed for hand function (power and dexterity) using a dynamometer, pinch gauge, grooved pegboard and Purdue pegboard. The EMG data was compared using the independent t-test. Hand function was compared using the independent t-test and the paired t-test. [Results] The results of study were as follows: the MVIC rate of change showed significant difference between the shoulder stabilization exercise group and the shoulder isometric resistance exercise group for the upper trapezius and serratus anterior. In the shoulder stabilization exercise group, power grip, pinch, grooved pegboard test and Purdue pegboard test results were significantly increased post-intervention. In the shoulder isometric resistance exercise group, pinch was significantly increased post-intervention, but the other test results showed no significant differences. [Conclusion] We conclude that shoulder stabilization exercise is more effective than shoulder isometric resistance exercise for shoulder stability and hand function.
Key words: Shoulder stabilization exercise, Shoulder isometric resistance exercise, Hand function

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INTRODUCTION

The hand functions are the most complicatedly constructed among human body functions and require sufficient strength and range of motion of not only the fingers and elbow joints but also the upper extremities and shoulder[1)]. In addition, for functional movements of the hands, appropriate muscle activation and coordination are required so that tasks can be performed accurately and quickly[2)]. For coordination, it is necessary to control strength accurately in terms of sequencing, timing and scaling and deficits in one or more of these item can cause coordination disorder. A

Table 1. Characteristics of subjects (n=19)

		SEG (n=11)	IREG (n=8)	Total (n=19)
Gender	Man	5 (45.5%)	4 (50%)	9 (47.4%)
	Woman	6 (54.5%)	4 (50%)	10 (52.6%)
Age (year)		22.73 ± 2.05	25.25 ± 2.38	23.79 ± 2.49
Height (cm)		167.91 ± 8.55	168.88 ± 8.56	168.32 ± 8.33
Weight (kg)		60.55 ± 10.51	64.88 ± 15.93	62.37 ± 12.84

Mean ± SD
SEG: Stabilization exercise group, IREG: Isometric resistance exercise group.

disorder in the control of sequence makes it impossible to activate the appropriate muscles in the correct sequence, resulting in unnecessary and non-functional movements in joints and muscles. Accordingly, abnormal synergy, co-activation and inter-joint coordination will appear[3].

Shoulder stabilization exercises are focused on the recovery of a balanced ability to control between shoulder stabilizers. Recently, closed kinematic chain exercises have frequently been used in therapeutic exercises of the upper extremities[4]. Closed kinematic chain exercises not only improve muscle strength and endurance but also trigger co-contractions of many muscles through mechanical compression of the plane of the joint and stimulate the mechanoreceptors around joints to provide more proprioception; thus, they are frequently used in therapy for dynamic stability and postural stability of the joints. Also, during voluntary movements of the upper extremities, scapular rotator cuff muscles control scapular positions; thus, when the upper extremities are moving, the rotator cuff muscles serve to stabilize the humerus and this enables good maintenance of length-tension curves. Therefore, if shoulder joints are stabilized, the performance ability of the upper extremities would increase and this would also greatly affect hand functions.

Muscle fatigue appears in diverse forms in environments of work, sports and daily living environments and it is an abstract wide-ranging concept. Generally, muscle fatigue is understood as a condition in which a subject is unable to give intensities of exercise or power required and is defined as a state in which the ability to generate muscle power has been reduced[5,6]. The causes of muscle fatigue are the exhaustion of chemical fuel for the activity of muscles coupled with a lack of the ability of the circulatory system to quickly remove the by-products of muscle metabolism, and insufficient oxygen supply and inadequate removal of metabolic products can occur when appropriate amounts of blood are not supplied to muscles. Thus, muscle fatigue will decrease the motor control capacity which will decrease the muscle maintenance capacity[7].

This study examined post-intervention changes in shoulder joint electromyography and the influence on hand functions in a healthy adult shoulder joint stabilization exercise group and a shoulder joint isometric resistance exercise group.

SUBJECTS AND METHODS

The subjects of this study were 19 healthy adults who had no problems with their musculoskeletal system. They were randomly divided into two groups as follows: a shoulder stabilization exercise group (n=11) and an isometric resistance exercise group (n=8) (Table 1).

A surface electromyography MP150 WSW (BIOPAC System Inc. CA, USA) was used to measure the activations of the upper trapezius, lower trapezius, serratus anterior muscles which were elected in order to measure changes in shoulder joint strength. The analog signals of surface electromyograms were sent to the MP150 WSW to be converted into digital signals which were filtered and processed using a personal computer and Acknowledge 3.7.3 (BIOPAC System Inc. Santa Babara, USA) software. The electromyographic signals were processed as follows. (1) Channels were designated so that electromyograph signals were received through each channel. (2) The sampling rate for the electromyograph signals was determined as 1,000 Hz (1,000 samples/second). (3) Amplified waveforms were filtered by 60–500 Hz band-pass filters. (4) To remove noise, 60 Hz notch filters were used. (5) To quantify the signals recorded while each muscle was contracted, the root-mean square (RMS) of the signal was calculated.

Power grips were measured using a Jamar hydraulic hand dynamometer (PC 5030JI, Preston Inc, America) and Pinches & Lateral pinches were measured using a Jamar hydraulic pinch gauge (PC 5030, Preston Inc, America).

The manual dexterity of the hand was measured using Purdue pegboards and grooved pegboards. The test-retest reliabilities of these tools developed by Joseph Tiffin in 1948 are 0.60–0.76. In this study, the Tiffin method was performed for 30 seconds and the number of times performed were used to measure scores.

Exercises were performed for 30 minutes by each group. The shoulder stabilization exercise group conducted stabilization exercises divided into a total of four stages using Thera-Bands and balls and each exercise method was performed 5 times for 30 seconds each time for 30 minutes. The shoulder isometric resistance exercise group performed 5 times for 30 seconds each time for 30 minutes using chairs or tables. The subjects were allowed to take a rest when they felt pain during the exercises.

All the statistics were processed using the SPSS/PC 12.0 for Windows program and the significance level α for all the statistics was determined as 0.05. To examine the general characteristics of the subjects, means, standard deviations and frequencies were calculated, the results of the pre- and post-intervention tests were tested by the paired t-test and variations in the pre- and post-intervention tests of the stabilization exercise group and the isometric resistance exercise group were calculated using the independent t-test. Finally, the correlations between the electromyography results of the shoulder muscles and the hand function in the shoulder stabilization exercise group were analyzed.

RESULTS

Variations between Pre-and post intervention test values of the shoulder muscle electromyography at the times of maximum voluntary isometric contractions were compared. In the electromyography of the upper trapezius at the maximum voluntary isometric contraction, the mean value increased by 12.26 mV post-intervention compared to pre-intervention in the stabilization exercise group, but decreased by an average –6.91 mV in the isometric resistance exercise groups and the difference between the two group was significant. In the electromyography of the lower trapezius at the maximum isometric contraction, the mean value decreased by –2.08 mV on average post-intervention compared to pre-intervention in the stabilization exercise group and decreased by an average –8.63 mV in the isometric resistance exercise group, but the difference between the two groups was not significant. In the electromyography of the serratus anterior at maximum isometric contraction, the mean value increased by 12.72 mV post-intervention compared to pre-intervention in the stabilization exercise group, but decreased by an average –4.06 mV in the isometric resistance exercise group, and the difference between the two group was significant (Table 2).

Table 2. Post-intervention change in muscle power (n=19)

	SEG Post-Pre variation (mV)	IREG Post-Pre variation (mV)
Upper Trapezius*	12.26 ± 16.15	–6.91 ± 9.07
Lower Trapezius	–2.08 ± 10.73	–8.63 ± 7.72
Serratus Anterior*	12.72 ± 21.32	–4.06 ± 4.59

Mean ± SD, * : $p<0.05$, SEG: Stabilization exercise group, IREG: Isometric resistance exercise group.

In power grip tests, the average power grip increased from 32.34 kg pre-intervention to 34.75 kg post-intervention in the stabilization exercise group and the difference was significant, while in the isometric resistance exercise group, the power decreased from 38.04 kg to 35.91 kg on average but the difference was not significant. In pinch tests, the average pinch power increased from 4.41 kg pre-intervention to 4.97 kg post-intervention in the stabilization exercise group and the difference was significant, while in the isometric resistance exercise group, the power decreased from 5.28 kg to 4.49 kg on average and the difference was significant. In lateral pinch tests, lateral pinch power increased from 6.95 kg pre-intervention to 7.17 kg on average post-intervention in the stabilization exercise group but the difference was not significant, while in the isometric resistance exercise group, lateral pinch power decreased from 7.5 kg to 6.93 kg on average, but the difference was not significant (Table 3).

Table 3. Comparison of hand power between pre-and post-intervention (n=19)

		Pre (Mean ± SD)	Post (Mean ± SD)
Power grip	SEG*	32.34 ± 9.74	34.75 ± 11.54
	IREG	38.04 ± 18.08	35.91 ± 18.48
Pinch	SEG*	4.41 ± 0.72	4.97 ± 1.24
	IREG*	5.28 ± 1.38	4.49 ± 1.21
Lateral pinch	SEG	6.95 ± 1.86	7.17 ± 2.28
	IREG	7.50 ± 2.85	6.93 ± 3.00

*:p<0.05, SEG=Stabilization Exercise Group, IREG=Isometric Resistance Exercise Group.

Table 4. Comparison of hand dexterity between pre-and post-intervention (n=19)

		Pre (Mean ± SD)	Post (Mean ± SD)
Grooved pegboard test	SEG*	11.18 ± 2.09	13.27 ± 1.62
	IREG	12.63 ± 2.33	12.00 ± 2.39
Purdue pegboard test	SEG*	15.27 ± 1.68	17.00 ± 2.45
	IREG	14.75 ± 1.91	14.00 ± 2.20

*:p<0.05, SEG=Stabilization Exercise Group, IREG=Isometric Resistance Exercise Group.

In the grooved pegboard, the number of times increased from 11.18 pre-intervention to 13.27 post-intervention in the stabilization exercise group and the difference was significant, while in the isometric resistance exercise group, the number of times decreased from 12.63 to 12.00 on average, but the difference was not significant. In the Purdue pegboard test, the number of times increased from 11.18 pre-intervention to 13.27 post-intervention in the stabilization exercise group and the difference was significant, while in the isometric resistance exercise group, the number of times increased from average 15.27 to 17.00 on average and the difference was significant, while in the isometric resistance exercise group, the number of times decreased from average 14.75 to 14.00 on average, but the difference was not significant (Table 4).

In the shoulder stabilization exercise group, correlations between the results of electromyography of shoulder maximum voluntary isometric contractions and hand power and function were analyzed. The results of electromyography of shoulder maximum voluntary isometric contraction and hand power, and hand power and hand function showed significant correlations at the upper trapezius. No particular correlation was shown in other areas (Table 5).

DISCUSSION

In this study, the activity of shoulder electromyography and hand power and hand function were examined, and correlations between the upper extremities and the hand were identified in a group that performed shoulder stabilization exercises and another group that performed isometric resistance exercises.

Relationships between the serratus anterior, the upper trapezius and the lower trapezius work to stabilize the scapula and as a primary movers in upward rotation of the scapular[8,9]. Therefore, neck or shoulder disorders appear due to lack of

Table 5. Correlation between shoulder MVIC EMG scores and hand strength and hand dexterity in the shoulder stabilization exercise group (n=19)

		UT	LT	SA	PG	P	LP	GP	PP
Shoulder MVIC EMG scores	UT								
	LT	.500							
	SA	.300	.200						
Hand Power	PG	.296	–.049	–.543					
	P	.100	.274	.050	–.018				
	LP	.681	.619	.062	.181	.152			
Hand Dexterity	GP	.562	.396	.371	–.014	–.423	.206		
	PP	–.151	.404	.076	–.219	.422	.452	–.135	

UT: upper trapezius, LT: lower trapezius, SA: serratus anterior, PG: power grip, P: pinch, LP: lateral pinch, GP: grooved pegboard, PP: Purdue pegboard coordination among these muscles which also result in scapular muscle instability[10,11]. It is considered that certain stabilization exercises can reduce pain and change muscle mobilization patterns. In addition, it has been reported that muscle strength improvement exercises also improve the stability of the vertebrae and the scapula and scapulohumeral rhythm[12]. In particular, although it is known that stabilization exercises using balls are more effective tools, the scientific evidence base is insufficient[13].

Electromyogram analyses are generally conducted on muscles in isometric resistance exercises[14], but surface electromyography has limitations depending on the areas where the electrodes are attached. In this study, in the case of the upper trapezius, two electrodes were attached to the upper crests of the shoulder between the 7th cervical spine and the acromion. In the case of the lower trapezius, a electrode was placed horizontally 2 cm laterally from the scapular spine.

The group that performed shoulder stabilization exercises showed a significant increase ($p<0.05$) of muscle activation increased at post-intervention compared to pre-intervention in the upper trapezius, lower trapezius, and serratus anterior, all of which are important stabilizers of the shoulder. In addition, hand power and hand function also increased. However, in the case of the isometric resistance exercise group, muscle activation decreased in all the three muscles and so did hand power and hand function. We consider that as shoulder stabilization muscles' activation increased, contractions and relaxations occurred appropriately and the stabilization exercises facilitated appropriate contractions while the functions were being performed. It was reported that while performing bench presses, most shoulder muscles showed activities and among them, the serratus anterior was especially activated[15], and the serratus anterior serves the role of properly positioning head of the humerus in the glenohumeral joint[16]. In addition, it was reported that when shoulder muscle activation was measured using therapeutic balls, the trapezius showed greater activation than the pectoralis major[17]. These results indicate that the trapezius and the serratus anterior are important for shoulder rehabilitation, and the ball exercise used as the method in this study is more effective than simple resistance exercises.

In the case of shoulder protraction, the serratus anterior primarily functions and in the case of retraction, the upper trapezius and the lower trapezius functions primarily function[18]. When isometric resistance exercises were performed on the shoulder flexor, shoulder protraction and retraction decreased significantly[19], because in such motions, the length and tension of the shoulder flexor change, and thus, the shoulder flexor is not properly positioned.

Based on the above mentioned results, we attempted to find correlations between the shoulder and the hand. Previously reported results suggest that there may be significant differences between the electromyograph activity of the shoulder and hand power and hand functions, but, in the present study, no particular correlations was shown because the number of subjects who participated in the study was small.

In conclusion, the shoulder stabilization exercises were more effective for increasing shoulder muscle activity than isometric resistance exercise. In addition, the stabilization exercises were more effective at increasing hand function and hand power; and although shoulder muscle activation and hand function were not significantly correlated, the stabilization exercises appeared to be more effective rehabilitation exercises than the isometric resistance exercises.

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