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Effects of Shoulder Stabilizing Exercise Using Sling on the Imbalance Ratio of Muscle Activitiy and Function in Patients with Chronic Shoulder Pain

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ABSTRACT

The aim of this study is to observe the effects of the shoulder stabilizing exercise using sling on the imbalance ratio of trapezius muscle activity and active range of motion (AROM) of shoulder joint. A total of 15 participants with chronic shoulder pain were participated and assigned into two groups; Intervention group that performed shoulder stabilization exercise for 4 weeks and control group that did not perform exercise. Muscle activities of the upper and lower trapezius muscle during 120-degree abduction and AROM during shoulder abduction were measured before and after 4-week intervention. As a result, there were significant changes both in the imbalance ratio and AROM after 4 weeks only in the intervention group ($p < 0.05$). In conclusion, shoulder stabilization exercise using sling would be effective in improving shoulder function by normalizing the imbalance ratio of muscle activity in terms of motor control.

1. Introduction

Shoulder lesions have been steadily increasing in recent years with the increase in the elderly population and the frequency of sports activities due to the extension of the average life span (Lindsay et al., 2000). In addition, due to the nature of shoulder disease, rehabilitation is required for a long time due to chronicity, and it is recognized as a social issue due to increased medical costs and loss of labor (Macfarlane et al., 1998).

Over the past five years, the national aging index has increased from 110.5 to 139.5 (Statistics Korea, 2018). In addition, as a result of analyzing shoulder lesions from 2010 to 2014, the number of people treated in 2014 was 2.053 million, an increase of 340,000 compared to 2010, and the proportion of hospitalization increased from 2.0% to 4.7 percent (Joo et al., 2017). In other words, with the increase in population aging, the number of shoulder lesions is also increasing.

Shoulder joints are joints with the largest range of motion among the joints of the human body, and are joints with both stability and mobility while having an unstable anatomical structure (Veeger & Van Der Helm, 2007). In order to maintain the intrinsic stability of the joint, muscles around

the shoulder are considered an essential factor for the normal function of the shoulder. At the same time, due to structural instability of the shoulder joint, muscles and ligaments around the joint are easily exposed to damage, resulting in shoulder joint pain in about 7-34% of the population (Solomonow, 2004; Sargin et al., 2022).

In particular, occupational groups such as athletes who repeatedly raise their arms above their heads are easily affected by shoulder disease (Zernicke & Whiting, 2000), and they complain of discomfort in their daily lives due to limited joint range due to pain. Those with such shoulder pain have muscle activity imbalance due to the weakened lower trapezius along with the shortening of the upper trapezius, and to this end, the shoulder function could be restored by adjusting the muscle activity ratio of trapezius muscles, which called imbalance ratio during shoulder exercise (De Mey, 2013).

So far, many studies have reported that various shoulder stabilization exercises were effective for shoulder pain, but demonstration on how they affect the muscle activities and imbalance ratio in terms of motor control are insufficient (Moghadam et al., 2020). Therefore, this study aimed to investigate on the effects of the shoulder stabilization exercise on muscle activities and imbalance ratio of upper and lower trapezius, and joint motion range of shoulder.

2. Literature review

2.1 Shoulder stabilization

Various shoulder stabilization exercises are designed to enhance shoulder stability and restore normal length-tension relationships in muscles around the shoulder (Voight & Thomson, 2000), as exercise programs that allow the shoulder to functionally perform movement in the neutral position. Recently, exercise to recover shoulder joint mobility and weakened shoulder muscles in a state where skin friction and gravity are removed by a suspension called sling as a shoulder stabilization exercise has been widely used. These movements have been verified as an effective method for integrated motion sensory training by using shaking strings and unstable support surfaces (Nasb & Li, 2016).

2.2 Imbalance ratio of trapezius muscle

Many studies have suggested that abnormal movement of scapula may be due to an imbalance of scapulothoracic muscle activity, and scientific evidences have been examined that upper trapezius muscle activation has increased in patients with shoulder disorder (Sahrmann, 2002; Ludewig et al., 2004; Ludewig & Cook, 2004). Especially, when considering the action of trapezius muscle contraction and the axis of motion of the scapula, the upper trapezius elevates and rotates the scapular upward, while the lower trapezius contracts to maintain horizontal and vertical equilibrium of the scapula. Therefore, the imbalance of force between the upper trapezius and the lower trapezius can lead to abnormal scapular movement in the patient with shoulder disorder (Johnson et al., 1994).

3. Methodology

3.1 Participants

This study was conducted on 15 adults with chronic nonspecific shoulder pain of at least 3 points with VAS for more than 6 months. All participants had no skeletal system problems such as fractures, and continued to complain of muscle pain. They voluntarily signed the consent form after receiving sufficient explanation of the study, and 7 out of 15 participants were randomly assigned into an intervention group applying shoulder stabilization exercise and the remaining 8 into a control group.

Table 1. Participant demographics

n=15	Control (n=7)	Intervention (n=8)
Sex (male/female)	4/3	4/4
Age (years)	61.32 ± 2.23	63.25 ± 3.72
Height (cm)	155.24 ± 1.62	157.51 ± 2.78
Weight (kg)	59.56 ± 3.12	60.22 ± 2.42
Skeletal muscle mass (kg)	20.42 ± 2.52	19.93 ± 1.12
Body fat mass (%)	35.12 ± 1.53	35.28 ± 3.27
BMI (kg/m^2)	26.16 ± 3.24	25.92 ± 2.23

3.2 Experimental procedure

This study was conducted three times a week for a total of four weeks, and each time, shoulder stabilization exercise using sling consisted of 5 minutes of warm-up exercise, 30 minutes of main exercise, and 5 minutes of final exercise. Shoulder stabilization exercise using sling was performed with experts with more than 3 years of experience in rehabilitation field. For the detailed sling exercise methods, referring to Chi and Kim (2019), pelvic lift, scapular retraction, supine shoulder abduction exercises were performed in supine position, and kneeling scapular protraction, kneeling scapular push-up and kneeling shoulder extension exercises were performed in prone position.

3.3 Outcome measurements

Before the start of the experiment and after the four-week intervention period, two groups measured the muscle activity of the upper and lower trapezius and the range of movement of the shoulder joint. Muscle activities were collected at 1,500 Hz by electromyogram (Noraxon, USA) and active range of motion during each participant performed shoulder abduction at 120 degrees with one's palm facing forward and then filtered with a band pass filter of 10 to 500 Hz after data collection. Next, the filtered data were demeaned, rectified by a root mean square (RMS) and normalized with maximum volatility isometric contraction (MVIC) of each participant. The average value was calculated after measuring the muscle activities three times. Before the attachment of electrodes

on muscles, the skin was wiped with alcohol to reduce skin resistance during signal recording.

As recommended by SENIAM (Stegeman & Hermens, 2007) the electrode of upper trapezius was attached at half of the line from the acromion to the spine on the 7th cervical vertebra and lower trapezius was at 2/3 on the line from the trigonum spinea to the 8th thoracic vertebra.

3.4 Statistical analysis

Data analysis was conducted using SPSS Ver 20. In order to compare the differences in muscle activity and joint motion range before and after the experiment within each group, nonparametric Wilcoxon signed-rank test was used, and Mann-Whitney U test was performed to find out the differences between the groups. The significance level was set at $p = 0.05$.

4. Results

4.1 Changes in muscle activity and imbalance ratio of trapezius

After 4 weeks of intervention, only the intervention group showed significant changes in both upper trapezius and lower trapezius muscle activity and imbalance ratio (Table 2). However, in the comparison between groups, there was a significant difference only in the upper trapezius muscle activity (P = .032).

Table 2. The changes in muscle activation and ratio after 4-week intervention

Variables (mV)	Intervention			Control		
	Pre	Post	*p*	Pre	Post	*p*
UT	82.20±1.92	78.80±1.92	.034*	83.40±1.81	82.60±1.67	.461
LT	84.80±2.16	82.80±1.48	.041*	85.40±1.51	85.00±1.58	.683
UT/LT	0.97±0.01	0.95±0.01	.043*	0.98±0.01	0.97±0.02	.686

* $P < 0.05$, LT: lower trapezius, UT: upper trapezius

4.2 Changes in range of motion

After 4 weeks of intervention, only the intervention group showed significant changes in AROM (Table 3). There was no significant difference in the comparison between groups.

Table 3. The changes in ROM after 4-week intervention

Variables (degree)	Intervention			Control		
	Pre	Post	*p*	Pre	Post	*p*
AROM	146.80±5.80	153.20±3.96	.43*	147.60±3.20	148.20±5.40	.892

* $P < 0.05$, AROM: active range of motion

5. Discussion

Optimized movement rhythm between bones of humerus, scapula and clavicle produces stable movement of the shoulder (Happee & Van der Helm, 1995). Especially, trapezius is a broad superficial muscle that covers all of these bones and has a significant effect on shoulder movement (Cools et al., 2002). This study investigated the effect of 4-week shoulder stabilization exercise on muscle activity of trapezius and active range of motion during 120-degree abduction in those with shoulder pain.

As a result, in this study, it was found that 4-week shoulder stabilization exercise using sling would significantly change muscle activity and imbalance ratio of trapezius, and active range of motion of shoulder, although there were no differences between the intervention and control groups. This was consistent with results of previous studies showing that shoulder stabilization exercises reduced shoulder pain and increased motor performance, and provides scientific evidence to support them (Gibson et al., 2004).

According to previous studies, shoulder stabilization exercise was effectively reported to improve shoulder joint movement range and upper limb function as an exercise method for stabilizing the scapula and normal recovery of muscles (Park et al., 2013; Jeon & Chon, 2018). Also, it has been reported that shoulder stabilization exercise using slings was effective in improving upper limb muscle strength and function. Especially, shoulder stabilization exercise was reported to significantly improve muscle activity of the upper trapezius on unstable ground compared to the flat ground (Lee et al., 2013), and most similar to the results of this study, other studies reported improvements in the range of the shoulder joint and the shoulder muscle activity of after stabilization exercise (Escamilla et al., 2009).

According to previous studies, it was reported that the imbalance ratio between the upper part and the lower part of trapezius was abnormally high in patients with shoulder pain (Smith et al., 2009). In other words, this study demonstrated that shoulder stabilization exercises using sling relaxed the shortening of the upper trapezius while enhancing the lengthening of the lower trapezius to lower the balance ratio. To sum up, through this study, it was found that the positive effects of these shoulder stabilization exercises on shoulder pain and function may be resulted from the restoration of imbalance ratio of trapezius muscle that led to restoration of the kinematic rhythm of bones constituting the shoulder.

Although this study has a limitation in that it is difficult to generalize the study results because 1) the number of participants is small and 2) their lifestyle habits are not directly controlled. Therefore, in order to develop a more effective exercise method for shoulder rehabilitation based on the results of this study in the future, it is necessary to compare the effects between various stabilization exercises on several clinical indicators such as muscle activities and imbalance ratio etc. for large sample size.

6. Conclusion

In conclusion, this study demonstrated that shoulder stabilization exercises using sling optimized the imbalance ratio of shoulder muscle activities in terms of motor control, thereby improving shoulder

function. In future studies, a better shoulder rehabilitation method in terms of cost effectiveness could be found by comparing the effects of various types of shoulder stabilization exercises on the imbalance ratio.

Conflict of interest statement

We hereby confirm that the manuscript has no any actual or potential conflict of interest with any parties, including any financial, personal or other relationships with other people or organizations within three years of beginning the submitted work that could inappropriately influence or be perceived to influence.

We confirm that the paper has not been published previously, it is not under consideration for publication elsewhere, and the manuscript is not being simultaneously submitted elsewhere.

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