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Comparison of Glenohumeral Stabilization Exercise and Scapular Stabilization Exercise on Upper Extremity Stability, Alignment, Pain, Muscle Power and Range of Motion in Patients With Nonspecific Shoulder Pain

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Abstract

Background: Shoulder stabilization commonly involves two components: the glenohumeral stabilization exercise (GSE) and scapular stabilization exercise (SSE). Despite the fact that the shoulder stabilization has advantageous merit, to our knowledge, only a few studies have compared the superior of the GSE and the SSE.

Objects: The purpose of this study was to assess the effects of GSE in patients with nonspecific shoulder pain.

Methods: Thirty subjects with nonspecific shoulder pain were randomly divided into an experimental group and control group, each with 15 patients. The experimental group used an GSE, whereas the control group did SSE. All subjects were measured in shoulder stability, scapular symmetric alignment, pain, muscle power, and range of motion before and after the intervention.

Results: GSE resulted in significantly better shoulder stability (p=.046, from 8.67±7.54 score to 13.93±9.40) in the experimental group compared with SSE in the control group. However, no significant effects were observed for scapular symmetric alignment including the angles of inferior scapular distance (p=.829) and inferior scapular height difference (p=.735), pain (p=.113), muscle power including shoulder flexion (p=.723) and abduction (p=.897) and range of motion including shoulder flexion (p=.853) and abduction (p=.472).

Conclusion: These findings suggest that GSE may be more effective in increasing the shoulder stability than the SSE in patients with nonspecific shoulder pain, probably through a centralization effect on the shoulder mechanism.

Key Words : Glenohumeral stabilization; Scapular stabilization; Shoulder pain; Shoulder stabilization; Upper extremity.

Introduction

Shoulder pain is the most common musculoskeletal symptom encountered in the primary clinical care setting, which represents a significant health problem associated with functional impairments (Walther et al, 2004). The prevalence of shoulder pain throughout the whole lifetime is estimated to be approximately 35% (Guerra de Hoyos et al, 2004). Shoulder problems were believed to be connected with abnormal muscle tension, spasms, and inflammation in the shoulder region like the rotator cuff syndrome as well as associated joints such as glenohumeral, scapulothoracic, sternoclavicular and acromioclavicular (Ratcliffe et al, 2014).

A variety of shoulder stabilization exercise including glenohumeral stabilization exercise (GSE) and scapular stabilization exercise (SSE) are used, although outcome studies have failed to provide clinical

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evidence for the superiority of any particular technique. In addition, despite the fact that all of these stabilization exercises have been used in the management of individuals with shoulder pain, it is difficult to reach a clinical decision in adopting any one of them because their therapeutic efficacy has yet to be demonstrated.

Many clinical trials investigating the different effects of management on shoulder problems including anti-inflammatory drugs, injection, laser therapy, ultrasound therapy, electric stimulation and therapeutic exercise have been widely used, but showed variable results (Sangwan et al, 2015; Voight and Thomson, 2000). For example, previous research examining the therapeutic effect of painless range of motion, strength and endurance showed enhanced returning to normal daily living activities, whereas other studies demonstrated little change in these outcome measures (Camargo et al, 2009; Faber et al, 2006). Furthermore, the underlying mechanism of therapeutic effect remains unclear because of a lack of quantitative measurement.

Recently, there has been growing interest in the application of shoulder stabilization techniques in the rehabilitation field for reducing pain and improving function in patients with shoulder pain. Shoulder stability is defined as the condition where in the humeral head remains in place or promptly returns to proper alignment within the glenoid fossa. Shoulder stabilization involves two components such as glenohumeral joint and scapula. With regard to GSE, the humeral head remains in the same location and promptly returns to the proper position within the glenoid fossa via a coupling force (Myers et al, 2006). Glenohumeral instability may result in dysfunction or pain due to repetitive microtrauma. Furthermore, this instability can contribute to the development of secondary rotator cuff disease or impingement (Sangwan et al, 2015), which has an adverse effect on shoulder's neuromuscular performance, resulting in subsequent shoulder injury (Voight and Thomson, 2000).

SSE focuses on balancing the trapezius, rhomboid, and serratus anterior muscles (Ludewig and Reynolds, 2009). Biomechanically, the scapular provides a stable base while the rotator cuff muscles provide dynamic force in order to maintain the humeral head in the glenoid fossa as glenohumeral movement occurs. Consequently, these occurs arise the dynamic stability by the scapulothoracic joint and associated with surrounding musculature (Ludewig and Reynolds, 2009). Therefore, the role of the scapular should be managed in the upper extremity, integrated scapular stabilization in order to maintain the scapular in the proper position with the length-tension relationships of the surrounding musculature (Grant et al, 2004).

To quantitatively investigate the effect of GSE on the scapular symmetric alignment using three dimensional spinal diagnostic imaging, this study focused on muscle power using hand-held dynamometer, range of motion using inclinometer and associated clinical outcome measures including shoulder stability and pain in patients with nonspecific shoulder pain. Our basic premise was that our GSE would significantly reduce the pain in patients with nonspecific shoulder pain, thereby improving shoulder stability, scapular symmetric alignment, muscle power and range of motion during daily activities.

Methods

Subjects

This study recruited 35 patients with nonspecific shoulder pain who visited a local hospital. Subjects were excluded if they had been advised by their physician to abstain from exercise, had chest pain, dizziness and hypertension. Five subjects were excluded because they declined to take part in this study. A total of 30 patients with nonspecific shoulder pain were recruited, and then they were randomly allocated into the experimental (n_1=15) or control group (n_2=15). Randomization was performed using sealed envelopes. A piece of paper in the sealed envelope was given to the subjects for group allocation. Allocation was conducted before the initial assessment. All the procedures were explained to the subjects, and each subject signed an informed consent form. General characteristics of the subjects are presented (Table 1).

Instruments

Upper extremity stability

We used the closed kinetic chain upper extremity stability test (Tucci et al, 2014). The subjects assumed a push-up position with each hand placed on a piece of tape on the floor while keeping the body as straight and as parallel to the ground as possible. The subjects' shoulders were positioned directly over his/her hands. When the examiner said "go", the subjects removed only one hand from the floor, touched the opposite line, and then returned the same hand to its original position on the line. A single test was comprised of continuing this alternating activity for 15 seconds. The test was performed twice for each subject in random order with a resting time of 1 minute. The subjects attempted as many touches as possible in the allotted time. The data of the two tests were averaged and recorded as the test scores. The closed kinetic chain upper extremity stability test has a reliability of .93 and a validity of .64 (Negrete et al, 2010; Tucci et al, 2014).

Three-dimensional spinal diagnostic imaging

Scapular symmetric alignment was determined using a three dimensional spinal diagnostic imaging system (Backmapper, ABW, Frickenhausen, Germany). This equipment precisely measured the form, location, and distortion of the spine structure from the forward, backward, upward, and downward directions. This device was used to analyze the position such as left and right heights of the scapula, which also analyzed the distribution of the musculoskeletal structure. Markers were attached on a level with the spinous process of the seventh cervical vertebra, both scapular inferior angle, both posterior superior iliac spine and sacrum. This three dimensional spinal diagnostic imaging system has a reliability of .93 and a validity of .64 (Golpayegani et al, 2013).

Pain intensity

Pain intensity was measured using a numeric rating scale (NRS). The NRS is a clinically standard instrument used to assess in patients with chronic pain. The NRS involved asking the patients to rate their pain from 0 (best) to 10 (worst), with 0 representing one end of the pain intensity. It has a reliability of .95 and a validity ranging from .86 to .95 (Hawker et al, 2011).

Muscle power

The strength of the shoulder girdle muscles was evaluated using a hand-held dynamometer (Microfet2, Hoggan Health Industries, West Jordan, USA). Isometric strength was assessed by maintaining at shoulder 90° abduction and flexion in a sitting position. Each muscle test was performed three times with a resting time of 30 seconds between each test, and the three tests were averaged. The hand-held dynamometer has a high intra-reliability and coefficient correlation of .78 for the validity (Jubany et al, 2015).

Table 1. General characteristics of subjects (N=30)

Parameters	Experimental group (n_1=15)	Control group (n_2=15)	t	p (two-tailed)
Age (year)	46.8±11.0[a]	51.9±7.8	-1.449	.159
Height (㎝)	162.2±7.8	160.0±8.9	.717	.479
Weight (㎏)	51.9±7.8	66.7±14.9	-.825	.417

[a] mean±standard deviation.

Range of motion (ROM)

The ROM was actively measured using an electronic inclinometer (Dualer IQ the smarter inclinometer, JTECH medical, Salt lake, USA) during shoulder flexion and abduction in sitting positions. The ROM test was performed three times consecutively without pain and the average of the tests was calculated. This device has a reliability of .95 and a validity of .85 (Kolber and Hanney, 2012).

Procedures

The subjects were engaged in either the experimental group (conventional physical therapy for 20 minutes followed by the GSE for 30 minutes) or control group (conventional physical therapy for 20 minutes followed by the SSE for 30 minutes). All subjects received conventional physical therapy for 20 minutes regardless of treatment allocation. Two physiotherapists were instructed in this study by the investigator (a physiotherapist with 20 years' experience). The GSE and SSE were administered one-on-one by one of the trained physiotherapists. The outcome assessments were measured before and after interventions. The physiotherapists undertaking the outcome assessment were blinded to group allocation.

Glenohumeral stabilization exercise

The GSE is a form of centralization of the glenohumeral joint. All movements consisted of 3 sets of 15 repetitions in four different directions such as right, left, anterior, and posterior in the glenohumeral joint with keeping the stability. The GSE involved 5 stages: (1) education how to maintain the humeral head in a neutral position in the glenohumeral fossa (2) grasping on the bar-stool with the shoulder 90° flexion and 90° abduction (3) placed subject's hand on the cushion ball in a sitting position (4) placed subject's hands on the cushion ball with shoulder-width apart at prone position on the bed (5) holding a .5 ㎏ weight in sitting position (Jaggi and Lambert, 2010; Moghadam et al, 2011; Sangwan et al, 2015) (Figure 1).

Scapular stabilization exercise

All movements consisted of 3 sets of 15 repetitions at a feeling without any pain or fatigue. The SSE consisted of 5 stages: (1) education for exact movements of the scapular in 4 different directions (2) shoulder external and internal rotation with the elbow 90° flexion in sidelying position (3) shoulder horizontal abduction at the prone position (4) shoulder 125° abduction combined with scapular protraction (5) placed subject's hands on the ground with shoulder-width apart at prone position on the bed, and then extended subject's elbows to push-up position for the protracting the scapular (De Mey et al, 2009; Hess et al, 2005) (Figure 2).

Statistical analysis

The data were analyzed using SPSS ver. 18.0 (SPSS Inc., Chicago, IL, USA). All variables were tested using the Kolmogorov-Smirnov test, which

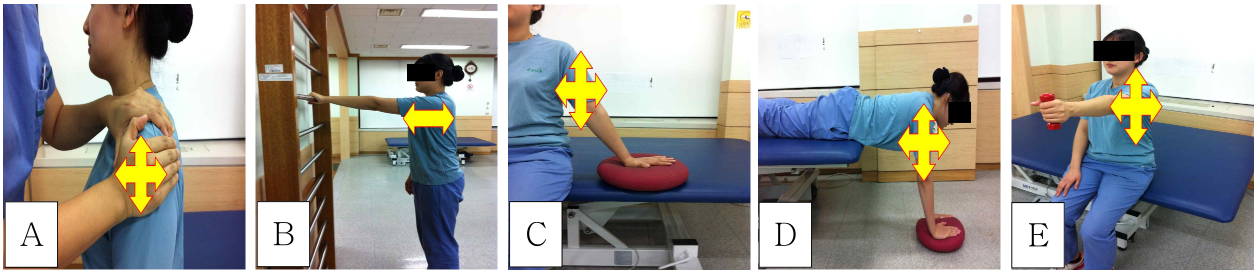

Figure 1. Glenohumeral stabilization exercise (A: education how to maintain the humeral head, B: grasping on the bar-stool, C: cushion ball in a sitting position, D: prone position on the bed, E: holding a weight in sitting position).

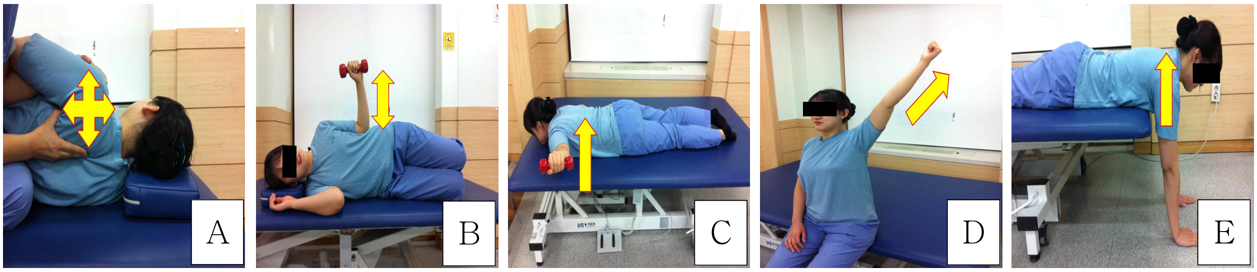

Figure 2. Scapular stabilization exercise (A: education for movements of the scapular, B: shoulder external and internal rotation, C: shoulder horizontal abduction, D: shoulder abduction combined with scapular protraction, E: push-up position for the protracting the scapular).

showed a normal distribution of the data. The independent t-test was used to determine significant differences in the general characteristics of the subjects between the groups. Two-way analysis of variance (ANOVA) with repeated measures was used to assess the main effects (group and time effects) and interaction effects of upper extremity stability, scapular symmetric alignment, pain, muscle power, and ROM between the groups. The significance level was set at a p value of <.05.

Results

Two-way ANOVA with repeated measures showed a significant group×time interaction effect for upper extremity stability (F=4.370, p=.046), suggesting that the GSE showed remarkable improvement compared with the SSE. Group effect was not significant observed for upper extremity stability (F=.345, p=.562). Time effect was significant observed for upper extremity stability (F=67.763, p<.001) (Table 2).

However, no significant group×time interaction effect was observed for angle of inferior scapular distance (F=.048, p=.829), angle of inferior scapular height difference (F=.117, p=.735). Group effect was not significant observed for angle of inferior scapular distance (F=.003, p=.958), angle of inferior scapular height difference (F=.000, p=1.000) (Table 3). Time effect was significant observed for angle of inferior scapular dis-

Table 2. The upper extremity stability before and after treatment in the experimental and control group

Variable		Experimental group (n_1=15)	Control group (n_2=15)	Group effect		Time effect		Interaction effect	
				F	p	F	p	F	p
UES[a] (score)	Before	8.67±7.54[b]	8.13±5.51	.345	.562	67.763	<.001	4.370	.046
	After	13.93±9.40	11.27±7.41						

[a]upper extremity stability, [b]mean±standard deviation.

Table 3. The scapular symmetric alignment before and after treatment in the experimental and control group

Variable		Experimental group (n_1=15)	Control group (n_2=15)	Group effect		Time effect		Interaction effect	
				F	p	F	p	F	p
AISD[a] (㎜)	Before	173.33±26.33[b]	177.80±20.76	.003	.958	49.745	<.001	.048	.829
	After	161.93±20.75	165.80±17.45						
AISHD[c] (㎜)	Before	8.80±4.75	8.53±4.97	.000	1.000	50.298	<.001	.117	.735
	After	3.00±2.36	3.27±3.70						

[a]angle of inferior scapular distance, [b]mean±standard deviation, [c]angle of inferior scapular height difference.

Table 4. The numeric rating scale before and after treatment in the experimental and control group

Variable		Experimental group (n_1=15)	Control group (n_2=15)	Group effect		Time effect		Interaction effect	
				F	p	F	p	F	p
NRS[a] (score)	Before	6.87±2.61[b]	6.20±2.11	.073	.789	59.555	<.001	2.680	.113
	After	4.20±1.93	4.46±1.96						

[a]numerical rating scale, [b]mean±standard deviation.

Table 5. The muscle power before and after treatment in the experimental and control group

Variable		Experimental group (n_1=15)	Control group (n_2=15)	Group effect		Time effect		Interaction effect	
				F	p	F	p	F	p
SFS[a] (N)	Before	25.42±14.60[b]	26.89±13.00	.042	.838	58.310	<.001	.128	.723
	After	34.76±14.89	35.39±14.70						
SAS[c] (N)	Before	25.47±15.49	24.79±16.23	.010	.923	65.600	<.001	.017	.897
	After	34.04±14.00	33.64±15.76						

[a]shoulder flexion strength, [b]mean±standard deviation, [c]shoulder abduction strength.

Table 6. The ROM before and after treatment in the experimental and control group

Variable		Experimental group (n_1=15)	Control group (n_2=15)	Group effect		Time effect		Interaction effect	
				F	p	F	p	F	p
SF[a] (degree)	Before	139.71±32.25[b]	139.82±31.70	.003	.958	49.745	<.001	.040	.853
	After	120.33±33.58	121.44±32.34						
SA[c] (degree)	Before	84.78±33.21	88.18±35.67	.001	.982	58.607	<.001	.533	.472
	After	120.64±37.14	117.80±36.63						

[a]shoulder flexion, [b]mean±standard deviation, [c]shoulder abduction.

tance (F=49.745, p<.001), angle of inferior scapular height difference (F=50.298, p<.001) (Table 3).

There is no significant group×time interaction effect was observed for pain (F=2.680, p=.113). Group effect was not significant observed for pain (F=.073, p=.789). Time effect was significant observed for pain (F=59.555, p<.001) (Table 4).

There is no significant group×time interaction effect was observed for shoulder flexion strength (F=.128, p=.723), shoulder abduction strength (F=.017, p=.897). Group effect was not significant observed for shoulder flexion muscle strength (F=.042, p=.838), shoulder abduction muscle strength (F=.010, p=.923). Time effect was significant observed for shoulder flexion muscle strength (F=58.310, p<.001), shoulder abduction muscle strength (F=65.600, p<.001) (Table 5).

There is no significant group×time interaction effect was observed for shoulder flexion ROM (F=.040, p=.853), shoulder abduction ROM (F=.533, p=.472). Group effect was not significant observed for shoulder flexion ROM (F=.003, p=.958), shoulder abduction ROM (F=.001, p=.982). Time effect was significant observed for shoulder flexion ROM (F=49.745, p<.001), shoulder abduction ROM (F=58.607, p<.001) (Table 6).

Discussion

This study demonstrated whether shoulder stabilization exercise could improve the shoulder stability, scapular symmetric alignment, pain, muscle power, and range of motion in patients with nonspecific shoulder pain. The upper extremity stability was significantly improved the experimental group (GSE) compared to the control group (SSE) as a centralization effect of the shoulder mechanism. Intervention-related changes in altered functions such as scapular symmetric alignment were successfully quantified by 3 dimensional spinal diagnostic imaging. These alignment changes in scapular symmetric measure were paralleled with increased stability of the upper extremity in GSE. The functional improvements were corroborated by the centralization effect instigated by the stability of the humeral head and glenoid fossa in the shoulder joint.

Previous studies have reported that the shoulder stabilization exercise had positive effects on the pain, muscle strength, and ROM in individuals with various shoulder problems (Moghadam et al, 2011; Roy et al, 2009). Yet, most of these studies relied on a few clinical measurements such as the NRS, manual muscle testing and ROM of the upper extremity without considering the need for more scientific and quantitative measurements. Although Roy et al (2009) recently demonstrated that the shoulder stabilization exercise is safe and has positive effects on stability and mobility in patients with nonspecific shoulder pain, there still remains a lack of a standardized method on shoulder function.

Various parameters such as upper extremity stability, pain intensity, muscle power and ROM of the shoulder part have been measured in shoulder stabilization exercise; however, in contrast to most variables examined in shoulder stabilization studies, shoulder function in patients with shoulder pain has only been measured using limited clinical measurements (Sangwan et al, 2015). Kinematic data obtained from 3 dimensional spinal diagnostic imaging could provide more valid information on shoulder function when combined with a quantitative dynamometer and electronic inclinometer data on muscle power and ROM, specifically indicating increased shoulder function. However, to our knowledge, no study has provided valid and reliable measurements, such as data obtained from 3 dimensional spinal diagnostic imaging analysis, on the effects of GSE compared with SSE in patients with nonspecific shoulder pain.

To improve the efficacy of the GSE and SSE, we used the exercise methods reported by Park et al (2013) for the shoulder pain patients. Several studies have reported the exercise methods for the application of the shoulder stabilization exercise (Cricchio and Frazer, 2011); however, specific exercise guidelines for shoulder pain are lacking and only short term effects have been reported. The effects of the shoulder stabilization exercise on hand grip muscle strength, non-electric manual ROM, and clinical measures of the upper extremity function in various patients have been examined (Jaggi and Lambert, 2010). In this current study, the subjects performed exercises consisted of specific 5 stages while exposed to the GSE and the SSE. In addition, exposure to GSE and SSE was limited to 30 minutes per session and 3 sets of 15 repetitions at a feeling without any pain or fatigue.

In this study, improved upper extremity stability was observed to a greater extent in the experimental group after the GSE. In fact, the present stability score among GSE group was increased by approximately 63% from 8 to 13 score after the intervention compared with that of the SSE alone, 37% from 8 to 11 score. Importantly, upper extremity stability is in line with the findings by a few previous studies (Jaggi and Lambert, 2010; Sangwan et al, 2015). In general, upper extremity stability and shoulder function in patients with shoulder pain is known to be strongly correlated (Moghadam et al, 2011; Myers et al, 2006). Although the interaction effects failed to achieve statistical significance, scapular symmetric alignment, pain intensity, muscle strength, and ROM in both groups showed a tendency to improve after interventions through the time effects, suggesting that patients with nonspecific shoulder pain showed improvement with all measures.

Notwithstanding its significant results, this research has a few limitations that should be addressed in a more robust and large-scale study. First, the numbers of subjects were very small. Second, this research represents immediate effects of the GSE in patients with nonspecific shoulder pain. Lastly, we didn't have a control group provided a baseline. Therefore, our results cannot be generalized because of limited sample size. A larger clinical controlled trial involving patients with shoulder pain is needed to investigate the therapeutic effects of GSE to augment upper extremity stability, scapular symmetric alignment, pain, muscle power and ROM in clinical practice.

Conclusion

This study suggests that the GSE is more beneficial than the SSE for improving upper extremity stability in patients with nonspecific shoulder pain. Certainly, both the GSE and the SSE are effective to the scapular symmetric alignment, pain, muscle power and ROM through the significant time effects of each measurement. These results offer clinical insight into the additive effect of GSE in upper extremity stability, and suggest that it may be used as an additional shoulder intervention technique for the management of nonspecific shoulder pain.

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