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The Effects of Scapular Stabilization Training using the Different Exercise Prop for Impingement Syndrome of Factory Workers

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Objective: The purpose of this studyaimed to investigate the effects of scapular stabilization training using the different exercise prop for impingement syndrome of factory workers.

Design: A randomized controlled trial

Methods: Twenty shoulder impingement syndrome subjects were randomly divided into two groups of ten subjects each. Inclusion criteria was presence of positive sign in at least two of Neer test, Hawkins test, Yocum test, Jobe test and Speeds test. Andexclusion criteria, those with surgical history of rotator cuff, those with disease in upper limb other than shoulder impingement syndrome, those who took anti-inflammatory drugs over the past 12 months were excluded from the sample. One group was performed scapula stabilization exercise using elastic bands, while dumbbell group performed the exercise using dumbbell. Both groups performed the exercise after applying the general physical therapy. After applying five days a week for a total of six weeks, range of motion of shoulder joint, muscle strength and pain and function level were evaluated.

Results: After the intervention, in both groups, all dependent variables at the 6-week post-test significantly improved compared with the pre-test ($p < 0.05$). In addition, elastic band exercise group showed a significant differences in SPADI function score and SPADI total score compared to the dumbbell group($p < 0.05$).

Conclusions: The elastic band training may be effective methodology using low-to-moderate intensity resistance for SPADI scores.

Key Words: Impingement syndrome, Scapular stabilization, Elastic band

Introduction

Musculoskeletal disorders are health problems generally appearing in working populations. Those who work at factories are repeatedly given burdens on their shoulder joints. Due to repeated collisions of subacromial structures, ruptures of the supraspinatus muscle tendon, degeneration become to occur [1]. Clinical shoulder joint disorders are related to exposure to continuous vibrations and repeated work [2]. Work-related musculoskeletal system disorders refer to disorders appearing on the neck, shoulder, waist, extremities, and muscles due to factors such as repeated motions, inadequate working postures, excessive use of force, body contact with sharp surfaces, vibrations, and temperatures [3]. Among these work-related musculoskeletal disorders, particularly upper extremity musculoskeletal disorder can have adverse effect not only on the restrictions of work-related activities but also difficulties in performing activities of daily living and sports and art activities [4].

As the importance of these musculoskeletal disorder has been increasing as one of industrial disasters,

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studies on the cause of occurrence, conditions, and treatment methods of work-related musculoskeletal system disorders have been conducted in diverse areas [5, 6]. Among them, stretching and muscle strengthening programs as treatment methods have been used as general methods of correcting muscles' abnormal activities and movements and relieving symptoms [7, 8]. Some studies reported that focus on improving scapular muscle recruitment training have beneficial effect [9, 10]. The scapula has various roles that anatomy and biomechanics interaction of scapula produce efficient movement on facilitating optimal shoulder function [11]. Also, high intensity resistance training has been coming to the fore as an integral part in diverse rehabilitation protocols [12]. High intensity resistance training is mainly used on occupational diseases related to neck and shoulder pain, rotator cuff damage, and post-operative muscle weakening of elderly patients [13]. For high level muscle activity, resistance training is generally implemented using machines or diverse tools [14, 15]. Most of machines were large and expensive. As an alternative to the machines, elastic bands and hand-held weights such as dumbbells are easy accessible and inexpensive tools that may be used in almost any situation [16].

Dumbbells and elastic bands are tools that are mainly used in therapeutic trainings to prevent shoulder disorders [17, 18]. Dumbbells and elastic bands can be applied to extremities adjusting the weights or the degree of resistance and can help muscle strengthening in the area of rehabilitation. Trainings using dumbbells are effective in muscle strengthening and pain relief. In addition, resistance trainings using elastic bands show wide ranged effects on rehabilitation exercises after injuries, health management, muscle strength, flexibility, and stability, and a study reported that when elastic band trainings were performed by healthy middle aged persons, effects such as muscle strength increases by 10~27%, stability enhancement, and basic physical strength improvement were shown [19, 20]. Anderson et al (2010) compared the muscle activation of a dumbbell and elastic band training related to upper extremity rehabilitation to estimate on 16 female workers [21]. The study found that both trainings are high levels of muscle activation, and therapist can select dumbbell or elastic band in rehabilitation. However, the study to compare the effects of dumbbell and elastic band implemented in subjects with shoulder impingement syndrome were not determined.

Therefore, the purpose of the present study is to implement trainings using dumbbell and those using elastic band for six weeks to find out how these trainings affect the ROM, muscle strength, pain and function of patients with shoulder impingement syndrome in order to provide treatment protocols effective at clinics.

Methods

Subjects

Among the workers who use the industrial rehabilitation center, the patients who are under treatment after being diagnosed with shoulder impingement syndromesyndrome by doctor in industrial rehabilitation center were selected as the subject of this study. A once-a-day general physical therapy that every hospital implements was applied to both groups, where experiment group performed scapula stabilization exercise using elastic bands and control group performed scapula stabilization exercise using dumbbell. The exercise was implemented right after applying the general physical therapy to both of the two groups. The 18 participants who listened to and understood the explanation about the purpose and process of the research were recruited for this study through bulletin board in industrial rehabilitation center. Inclusion criteria was presence of positive sign in at least two of Neer test, Hawkins test, Yocum test, Jobe test and Speeds test [22]. As for the exclusion criteria, those with surgical history of rotator cuff, those with disease in upper limb other than shoulder impingement syndrome, those who took anti-inflammatory drugs over the past 12 months were excluded from the sample.

Before selecting the number of samples, a pilot experiment was conducted on three patients who received scapula stabilization exercise using elastic bands and three patients who received scapula stabilization exercise using dumbbell.G-power program

Table 1. Subject characteristics

Variable	Dumbbell (n=9) Mean ± SD	Band (n=9) Mean ± SD	t	p
Age (y)	43.3±6.56	42.8±7.72	0.15	0.87
Career (y)	11.6±4.37	11.2±3.32	0.23	0.82
Duration of symptoms (m)	20.9±4.33	21.4±5.87	−0.21	0.83
Body Height (cm)	168.2±6.92	168.6±5.89	−0.85	0.40
Body Mass (kg)	68.4±5.71	71.1±8.17	−0.13	0.89
BMI (kg/m^2)	24.18±2.11	25.11±3.49	−0.71	0.48

The values are presented mean (SD)
BMI: body mass index

analysis results for the sample size calculation showed test power of significance level (0.05) and effects size (1.46). The results indicated that 9 subjects in each group were appropriate to obtain 80% test power. The subject of this study is described in Table 1.

Outcome Measurements

Before the experiment, muscle strength, range of motion(ROM) of shoulder joint and pain level, function level of shoulder joint of all subjects were evaluated at a preliminary test. The results of the training were measured on the day after the day on which all exercise programs were completed, and around 30 minutes to 1 hours was taken for the measurement of the results. The outcomes of the intervention were evaluated by using the dumbbell and elastic band and measuring the aim of data for the changes in the 2 exercises.

1) Shoulder joint range of motion (ROM)

A goniometer was used for ROM measurement of shoulder joint that is generally used by physical therapists when measuring joint angles (SPADI, ICC =.78~.82). The angle of shoulder joint abduction, flexion, external rotation and internal rotation were measured. ROM evaluation measured the joint angle after voluntary movement within a range of no pain for three times and the average value was used as the final measures. A 20-second resting time was given between each measurement. To minimize the impact from the order of measuring joint angles, the measurement was performed by randomly choosing the order [23].

2) Evaluation of muscle strength in shoulder joint

As for the muscle strength in shoulder joint, muscle strength was measured in each case of flexion, abduction, external rotation and internal rotation of the shoulder joint. A hand-held dynamometer was used for the measurement(SPADI, ICC=.89~.92). The muscle strength evaluation was measured before and after the scapula stabilization exercise. For the flexor muscle strength test, the patients performed 90 degree flexion of shoulder in a correct sitting position and were told to support the hand-held dynamometer put on the elbow joint for the measurement. For the abductor muscle test, the patients performed 90 degree abduction in a correct sitting position and were told to support the hand-held dynamometer put on the elbow. The external rotation and internal rotation was performed by putting pillow or towel on the upper arm of the patients in a prone position. For measuring the muscle strength in external rotation, elbow was in 90 degree flexion, shoulder was in 90 degree abduction and 90 degree external rotation and the patients were told to support the hand-held dynamometer put on the proximal part of wrist joint. Similarly, for measuring the muscle strength in internal rotation, elbow was in 90 degree flexion, shoulder was in 90 degree abduction and 90 degree external rotation and the patients were told to support the hand-held dynamometer put on the proximal part of wrist joint. All muscle strength

evaluations were measured in a condition of isometric contraction for three seconds and the average from three times of measurements was used as a final value. A 30-second resting time was given between each measurement. To minimize the impact from the order of the test, muscle strength test was performed by randomly choosing the order [24].

3) Evaluation of upper limb pain and disability level

To evaluate the disability level in upper limb, shoulder pain and disability index (SPADI, ICC =.64~.66) that is frequently applied to patients with shoulder joint disease was used. This index consists of 13 sub items, among which five items related to pain were measured where score of 0 indicated no pain and score of 10 indicated severe pain, giving a total score range between 0-50. There are eight items related to shoulder disability where score of 0 indicated no disability and score of 10 indicated inability to perform functions due to severe disability. In this study, SPADI score range was between 0-130 by adding the scores of shoulder joint pain and disability item [25].

Procedure and exercise

In this study, patients who satisfy the selection criteria were randomly divided into control group and experiment group beforehand. As for the classifying method, two small balls with numbers one (Dumbbell group) and two (elastic band group) written on them were put in a bag and the subjects picked up the ball whose number indicated their classification into either dumbbell group (10 patients) or elastic band group (10 patients). Afterwards, each of hot pack and interferential current therapy was applied in a physical therapy room to both of dumbbell group and elastic band group once a day as a general physical therapy. Elastic band group performed scapula stabilization exercise using elastic bands, while dumbbell group performed the exercise using dumbbell. Both groups performed the exercise after applying the general physical therapy. After applying a daily 30-minute exercise for five days a week for a total of six weeks, ROM of shoulder joint, muscle strength and pain and function level were evaluated.

Intervention progression

Agents inphysical therapy(heat and electric)

As for the agents in physical therapy, an intervention method commonly practiced on patients with pain that consists of 10-minute hot pack (Fomenting appliance, Peoples, China) at 80℃, 15-minute interferential current therapy (MS-2500J, KMG, Korea) using 2000~2500Hz and 5-minute ultrasonic treatment(HS-502, HANIL TM, Korea) using 0.8~1MHz were implemented for a total of 30 minutes [26].

Scapula stabilization exercise

The scapula stabilization exercise applied in this research consists of five-minute warm-up exercise, 20-minute main exercise and five-minute wrap-up exercise, referring to the exercise method implemented by De Mey (2012) [10]. Damage from the exercise program was prevented by performing stretching for five minutes during the warm-up and cool-down exercises. In this scapular stabilization exercise was performed in the same way as the motions mentioned in Table 2 using other tools such asthera-bands and dumbbells. The exercise program that was implemented as a main exercise consists of prone lateral extension (1), forward flexion in sidelying (2), external rotation in sidelying (3), and prone horizontal abduction with external rotation (4) (Table 2). Each exercise was implemented for 10-15 times for three sets follow the training sessions and 1-minute resting time was given between each set. The scapular stabilization exercise program was progressively increased repetitions during 6-week exercise program. Subjects were asked to perform three sets of 10 repetition during the first and second weeks, progress to three sets of 15 repetitions during each session in the third and four week, progress to three sets of 20 repetitions during the five and six week. Table 2 describes the detailed explanation about the exercise method. In this study, the scapula stabilization exercise was implemented for six weeks since this period is known to have the most significant improvement[27]. Before starting the exercise program, the therapist educated the subjects about four exercises pictures and explanation manual.

Table 2. Scapular stabilization exercise program

Exercise	name of exercise	method	exercise time
Warm-up exercise	stretching exercise	pectoralis minor and posterior shoulder stretching and pain-free AROM in flexion and abduction standing	5 minute
	prone lateral extension	The subject is prone with the shoulders resting in 90 degree of forward flexion. From this position, the subject performs lateral extension to a neutral position with the shoulder in neutral rotation.	5 minute
main exercise	Forward flexion	The subject is in a side-lying position, with the shoulder in neutral. The subject performs 90 degree of unilateral forward flexion in a sagittal plane.	5minute
	External rotation	The subject is side lying with the shoulder in neutral position and the elbow flexed 90 degree. From this position, the subject performs 90 degree of external rotation of the shoulder with a towel between the elbow and trunk to avoid compensatory movements.	5 minute
	Prone horizontal abduction with external rotation	The subject is prone with the shoulders resting in 90 degree of forward flexion. From this position, the subject performs horizontal abduction to a horizontal position, with an additional external rotation of the shoulder at the end of the movement.	5 minute
Cool-down exercise	stretching and ROM exercise	pectoralis minor and posterior shoulder stretching, thoracic spine self-mobilization into extension, and pain-free AROM in flexion and abduction standing	5 minute

The values are presented mean (SD)
BMI: body mass index, ROM: range of motion, AROM: active range of motion

The exercise was implemented on the damaged side shoulder of all subjects. Each exercise was repeated for 10 times in each set and the set was performed for three times, with a one-minute resting time between the sets. The initial intensity was determined for each individual through the 10 repetition maximum (RM) testing[28]. In the week before the experiment, the 10 RM load was assessed for each subject by determining the maximum weight that could be performed for 10 consecutive repetitions. Dumbbell and elastic band with different resistance are provided to the subjects and 10 RM test conducted to identify the resistance with an appropriate, individualized resistance. If the subject could not accomplish the 10RM on the first attempt, the load adjusted by 1-5 kg, and a minimum of 5 minutes of rest was given before the next attempt. 10 RM test was performed 10 repetition of exercise using acceptable resistance of dumbbell or elastic band. 10 RM test was measured for all exercises in exercise program, to determine the load. The subjects familiarized themselves with the physical therapist by performing each exercise to 10 RM test. A therapist supervised the whole exercise process from the side during the exercise to control exact motion pattern and intensity.

Statistical analysis

All data were analyzed using statistics program PASW statistics ver. 18.0 (SPSS, Chicago, IL, USA) for Windows. Descriptive statistics were analyzed to examine the general characteristics of research subjects, which were presented in mean, standard deviation. Normality was examined using One-sample

Kolmogorov-Smirnov test. Descriptive statistics were performed to illustrate the subject characteristics of age, career, duration of symptoms, body height, body mass and BMI were analyzed using independent t-test to determine if differences between the groups existed. Independent t-tests were used to compare differences between group means and paired t-test was used to compare within group means. For the analysis of statistical significance, a significance level was set at $p < 0.05$.

Results

The findings of ROM, muscle strength, pain level and functional level scores are presented in Figures 1-3. There were no significant differences in all dependent variables between groups at the baseline. After the intervention, in both groups, all dependent variables at the 6-week post-test significantly improved compared with the pre-test. Significant differences in the post-test values were observed for SPADI function score and SPADI total score. The range of shoulder abduction increased significantly by 50.09% in the dumbbell group and 59.64% in the elastic band group. The range of shoulder flexion increased significantly by 5.10% in the dumbbell group and 5.59% in the elastic band group. The range of shoulder internal rotation increased significantly by 29.93% in the dumbbell group and 35.54% in the elastic band group. The range of shoulder external rotation increased significantly by 22.66% in the dumbbell group and 37.11% in the elastic band group. The power of shoulder abduction increased significantly by 28.45% in the dumbbell group and 52.21% in the elastic band group. The power of shoulder flexion increased significantly by 13.48% in the dumbbell group and 40.38% in the elastic band group. The power of shoulder internal rotation increased significantly by 25.58% in the dumbbell group and 44.93% in the elastic band group. The power of shoulder external rotation increased significantly by 33.28% in the dumbbell group and 65.37% in the elastic band group. The score of SPADI pain reduced significantly by 39.39% in the dumbbell group and 47.88% in the elastic band group. The score of SPADI function reduced significantly by 17.08% in the dumbbell group and 31.57% in the elastic band group. The total score of SPADI reduced significantly by 23.99% in the dumbbell group and 36.71% in the elastic band

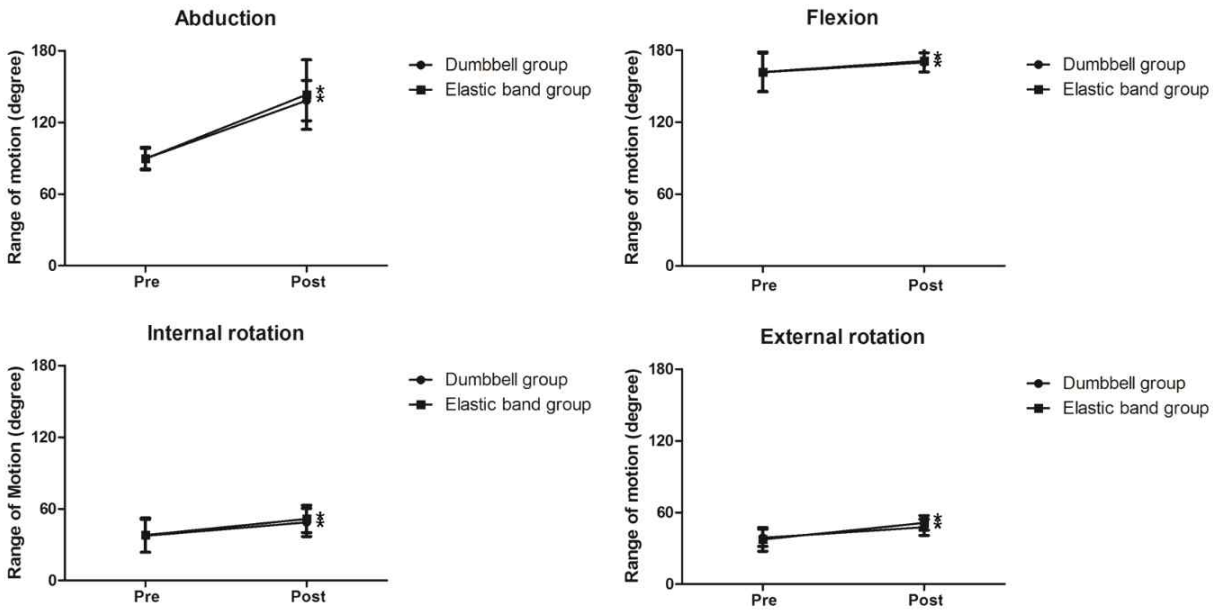

Figure 1. Difference of ROM (mean ± standard deviation) between pre-test and post-test within the two groups. The asterisks (*) indicate significant differences between the pre-test and post-test ($p < .05$).

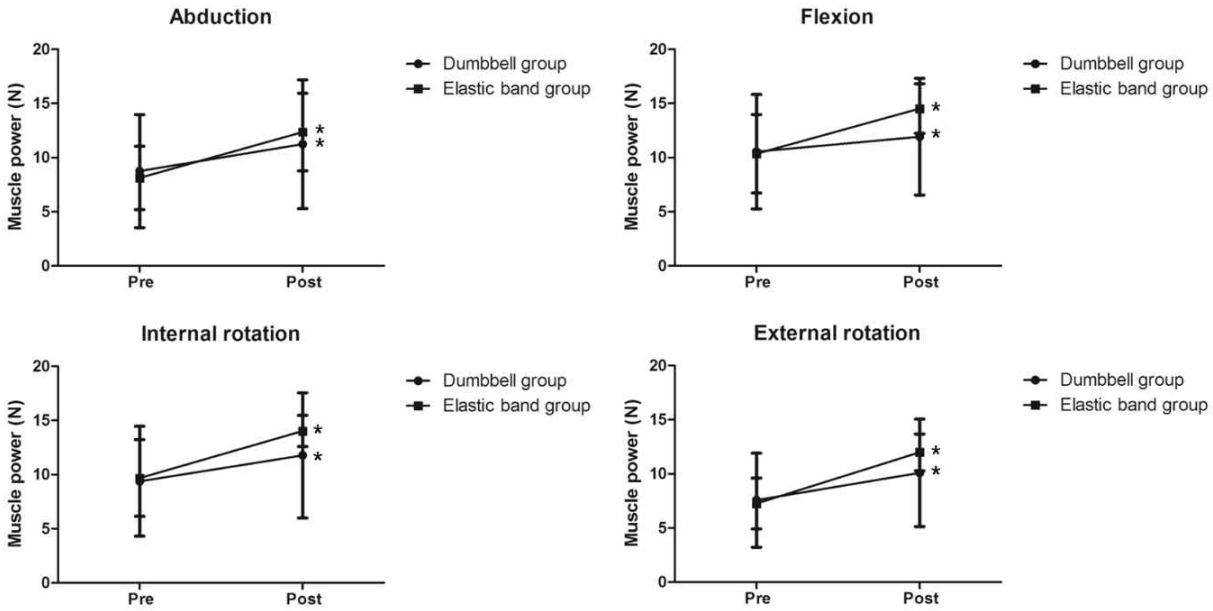

Figure 2. Different of muscle power (mean ± standard deviation) between pre-test and post-test within the two groups. The asterisks (*) indicate significant differences between the pre-test and post-test ($p < .05$).
group.

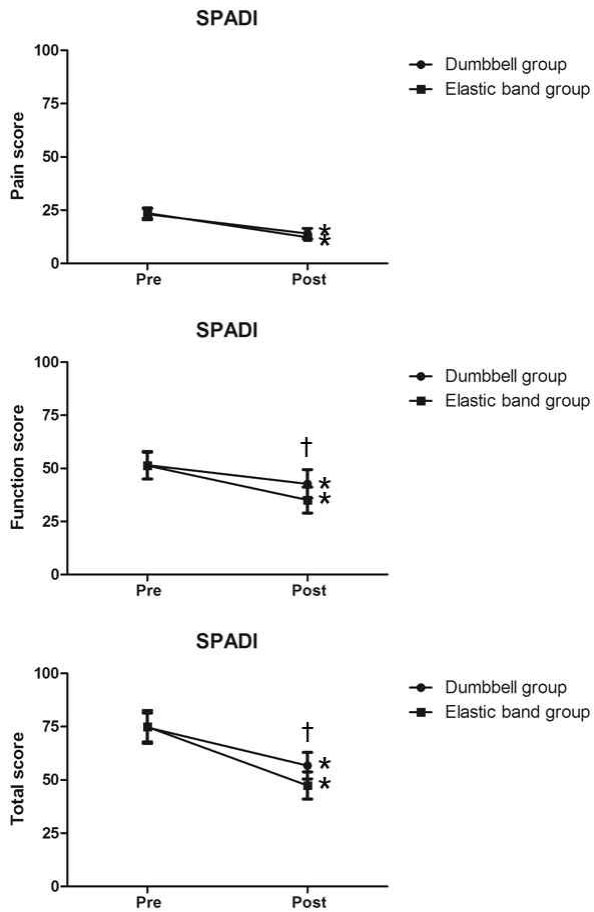

Figure 3. Different of pain and functional level (mean ± standard deviation) between pre-test and post-test within the two groups. The asterisks (*) indicate significant differences between the pre-test and post-test, and the cross (†) indicates a significant difference between the post-tests after the 6-week training ($p < .05$).

Discussion

This study was conducted to investigate whether 6 week dumbbell exercise or elastic band exercise can change ROM, muscle strength and pain level and functional level of shoulder. This study indicates that the six week exercise, both groups showed significant differences in the ROM, muscle strength, pain level and functional level of shoulder compared with the baseline with simple and inexpensive exercise equipment. Between the post-test values, elastic band exercise group demonstrated significant increase for function of shoulder compared with the dumbbell group ($p < 0.05$).

All range of the shoulder significantly improved in both groups following training. In addition, in the elastic band group, abduction, flexion, internal rotation, external rotation improved by 9.3, 8.76, 15.78, and 38.93%, respectively, compared with the dumbbell group. In general, excessive activation of the upper trapezius with decreased adjustment the lower trapezius and the serratus anterior leads to abnormal motion and limitation of shoulder movement. Many studies reported that excessive activation of the upper trapezius combined with decreased control the lower trapezius and serratus anterior contribute to abnormal scapular motion [29]. Altered scapular positioning and motor control are lead to shoulder impingement syndrome as important risk factors [30, 31]. Our study performs four exercises that focused on muscle balance and UT (upper trapezius) / LT (Lower trapezius) ratio. The three exercises (prone lateral extension, external rotation, horizontal abduction with external rotation) of our study were reported that with a low UT/LT ratio [32] and horizontal abduction with external rotation exercise was activated middle and lower trapezius[33]. The horizontal abduction with external rotation exercise frequently is promoted for optimal shoulder rehabilitation [34, 35]. Townsend et al [35] as well as Moseley et al [36] included this exercise in their selection for glenohumeral and scapulothoracic muscle strengthening programs. Cools et al [32] suggested that side-lying external rotation and side-lying forward flexion are recruit the middle trapezius with minimal activity in the upper trapezius. Also, the side-lying external rotation exercise enhances activity in the supraspinatus, infraspinatus, teres minor, and posterior deltoid [35]. De Mey et al [10] reported that overhead athletes with impingement symptoms show decreased activity in the lower trapezius and middle trapezius with excessive activation of the upper trapezius after scapular muscle rehabilitation exercise [37]. The scapular stabilization exercise is used to correct abnormal scapular placement and functional movement disorder and especially provides stability to entire scapula [38]. This mechanism leads to increased range and reduced pain of shoulder. Therefore, both groups improved range of the shoulder. Also increase of shoulder ROM may be due to reducing shoulder pain in patients. In our study, the both groups significantly improved in pain index of SPADI after 6-weeks training. Elastic band training is performed at a low-to-moderate intensity following length of band. Many studies have reported that muscle strength and endurance capacity can be improved following elastic resistance training [39]. Elastic band training produced less muscle hypertrophy than weight machines and induced minor changes in muscle fiber size and fiber-type composition compared with high-intensity resistance training [40]. Thus, elastic band group may be improve function of shoulder.

All power of the shoulder significantly improved in both groups following training. In addition, in the elastic band group, abduction, flexion, internal rotation, external rotation power improved by 45.5, 66.61, 43.06, and 49.08%, respectively, compared with the dumbbell group. The restoration of muscle imbalance is a result of training, as increased strength leads to increased muscle activation with lower part of trapezius [41]. Also, previous studies reported that strengthening of rotator cuff and scapulothorasic muscles is important in rehabilitation of patients with shoulder impingement syndrome [42]. Thus, exercises of our study may be improved for restoration of both muscle imbalances. The Baskurt et al [9] reported that patients with shoulder impingement syndrome improved strengths of rotator cuff and scapular muscle after 6-week scapular stabilization exercise. They suggested that increased strength caused by effect of providing glenohumeral rhythm, increasing the subacromial space

and decreasing pain. In our study, the scapular stabilization exercise program was progressively increased repetition follow the training sessions. The progressive resistance exercise have beneficial effects such as muscle performance, connective tissue and bone [43, 44]. May studies within the patients with shoulder impingement syndrome have demonstrated positive effects of exercise interventions on muscle strength [45]. Lombardi et al [46] divided 60 patients with shoulder impingement syndrome into two groups of 30 patients and applied the progressive resistance exercise program to patients with shoulder impingement syndrome for twice a week for 2 months. When the training was completed, the progressive resistive exercise group displayed improved strength.

All score of the SPADI significantly improved in both groups following training. In addition, in the elastic band group, pain score, function score and total score of SPADI reduced by 17.73, 45.89, and 34.64%, respectively, compared with the dumbbell group. The improvement in function may be related to an improvement regarding pain and strength. The intervention focused on scapular stabilizing muscle is commonly applied for the patients with shoulder impingement syndrome [47]. De Mey et [10] al reported that the scapular muscle rehabilitation exercises similar to exercises of our study for 6-weeks improve pain and function based on SPADI scores. The results of elastic band group indicate that a 6-week scapular stabilization exercise significantly improved function based on SPADI scores than dumbbell group. Anderson et al [22] investigated that the sixteen healthy female workers measured muscle activation during resistance exercises of upper-extremity. Anderson et al suggested that dumbbell and elastic band with regard to muscle activation showed clear similarities. The results of our study showed similar effect of exercise with dumbbell and elastic band. Although Anderson's study not specifically investigated, differences of dumbbell and elastic band, it may some differences exist. The function based on SPADI scores significantly improved in elastic band group than dumbbells groups. Elastic band provide increasing resistance with elongation, while dumbbells provide isotonic resistance [48].

There are few limitations in this study. First, the results of follow-up measures were not performed, thus the carry-over effect of both exercises could not be determined. Second, the subjects and examiner were not blinded to the group allocation. The examiner supervised all exercise sessions and all measurements. Third, our results should not be generalized to all patients with shoulder impingement syndrome. The patients in this study were adults with chronic impingement syndrome, thus are not a representative sample of patients with shoulder impingement syndrome. Finally, the interventions in our study included four exercises. Therefore, it would be impossible to determine which exercise of the interventions led to the improvements.

Conclusion

This study compared the effects of dumbbell and elastic band exercise on the ROM, strength, pain and function in patients with shoulder impingement syndrome. Our finding suggests that elastic band exercise is beneficial for improving function based on SPADI scores. The elastic band training may be effective methodology using low-to-moderate intensity resistance. The results of our study will provide useful information for future studies on more effective methodology of improving the shoulder function of patients of shoulder impingement syndrome are needed.

References

1. Neer CS. Impingement lesions. Clin Orthop Relat Res. 1983;173:70-7.
2. Järvholm U, Styf J, Suurkula M, Herberts P. Intramuscular pressure and muscle blood flow in supraspinatus. Eur J Appl Physiol Occup Physiol. 1988;58(3):219-24.
3. Health UDo, Services H. Musculoskeletal disorders and workplace factors. A critical review of epidemiologic evidence for workrelated musculoskeletal disorders of the neck, upper extremity and low back. 1997;134-5.

4. Angst F, Goldhahn J, Drerup S, Flury M, Schwyzer H-K, Simmen BR. How sharp is the short QuickDASH? A refined content and validity analysis of the short form of the disabilities of the shoulder, arm and hand questionnaire in the strata of symptoms and function and specific joint conditions. Qual Life Res. 2009;18(8):1043-51.
5. Buckle PW, Devereux JJ. The nature of work-related neck and upper limb musculoskeletal disorders. Appl Ergon. 2002;33(3):207-17.
6. Barr AE, Barbe MF, Clark BD. Work-related musculoskeletal disorders of the hand and wrist: epidemiology, pathophysiology, and sensorimotor changes. J Orthop Sports Phys Ther. 2004; 34(10):610-27.
7. Bang MD, Deyle GD. Comparison of supervised exercise with and without manual physical therapy for patients with shoulder impingement syndrome. J Orthop Sports Phys Ther. 2000;30(3):126-37.
8. Wang CH, McClure P, Pratt NE, Nobilini R. Stretching and strengthening exercises: their effect on three-dimensional scapular kinematics. Arch Phys Med Rehabil. 1999;80(8):923-9.
9. Başkurt Z, Başkurt F, Gelecek N, H Özkan M. The effectiveness of scapular stabilization exercise in the patients with subacromial impingement syndrome. J Back Musculoskelet Rehabil. 2011;24(3):173-9.
10. De Mey K, Danneels L, Cagnie B, Cools AM. Scapular Muscle Rehabilitation Exercises in Overhead Athletes With Impingement Symptoms Effect of a 6-Week Training Program on Muscle Recruitment and Functional Outcome. Am J Sports Med. 2012;40(8):1906-15.
11. Voight ML, Thomson BC. The role of the scapula in the rehabilitation of shoulder injuries. J Athl Train. 2000;35(3):364.
12. Taylor NF, Dodd KJ, Damiano DL. Progressive resistance exercise in physical therapy: a summary of systematic reviews. Phys Ther. 2005;85(11):1208-23.
13. Andersen LL, Kjaer M, SØgaard K, Hansen L, Kryger AI, Sjögaard G. Effect of two contrasting types of physical exercise on chronic neck muscle pain. Arthritis Rheum. 2008;59(1):84-91.
14. Braun S, Kokmeyer D, and PJ, Millett. Shoulder injuries in the throwing athlete. J Bone Joint Surg. 2009;91(4):966-78.
15. Suetta C, Andersen JL, Dalgas U, Berget J, Koskinen S, Aagaard P, et al.Resistance training induces qualitative changes in muscle morphology, muscle architecture, and musclefunction in elderly postoperative Patients. J Appl Physiol. 2008;105(1): 180-6.
16. Andersen LL, Magnusson SP, Nielsen M, Haleem J, Poulsen K, Aagaard P. Neuromuscular activation in conventional therapeutic exercises and heavy resistance exercises: implications for rehabilitation. Phys Ther. 2006;86(5):683-97.
17. Rogers ME, Sherwood HS, Rogers NL, Bohlken RM. Effects of dumbbell and elastic band training on physical function in older inner-city African -American women. Women Health. 2002;36(4):33-41.
18. Kisner C, Colby LA. Therapeutic exercise: foundations and techniques: FA Davis; 2012.
19. Andersen LL, Saervoll CA, Mortensen OS, Poulsen OM, Hannerz H, Zebis MK. Effectiveness of small daily amounts of progressive resistance training for frequent neck/shoulder pain: randomised controlled trial. Pain. 2011;152(2):440-6.
20. Brill PA, Drimmer AM, Morgan LA, Gordon NF. The feasibility of conducting strength and flexibility programs for elderly nursing home residents with dementia. Gerontologist. 1995;35(2):263-6.
21. Mikesky AE, Topp R, Wigglesworth JK, Harsha DM, Edwards JE. Efficacy of a home-based training program for older adults using elastic tubing. Eur J Appl Physiol Occup Physiol. 1994;69(4):316-20.
22. Andersen LL, Andersen CH, Mortensen OS, Poulsen OM, Bjørnlund IBT, Zebis MK. Muscle activation and perceived loading during rehabilitation exercises: comparison of dumbbells and elastic resistance. Phys Ther. 2010;90(4):538-49.
23. Magee DJ. Orthopedic physical assessment: Elsevier Health Sciences; 2014.
24. Barnes CJ, Van Steyn SJ, Fischer RA. The effects of age, sex, and shoulder dominance on range of motion of the shoulder. J Shoulder Elbow Surg. 2001;10(3):242-6.
25. Bohannon RW. Reference values for extremity muscle strength obtained by hand-held dynamometry from adults aged 20 to 79 years. Arch Phys Med Rehabil. 1997;78(1):26-32.
26. Roach KE, Budiman-Mak E, Songsiridej N,

Lertratanakul Y. Development of a shoulder pain and disability index. Arthritis Rheum. 1991;4(4): 143-9.
27. Homayouni K, Naseri M, Zaravar F, Zaravar L, Karimian H. COMPARISON THE EFFECT OF AQUATIC PHYSICAL THERAPY AND CONVENTIONAL PHYSICAL THERAPY IN PATIENTS WITH LUMBAR SPINAL STENOSIS (A RANDOMIZED CONTROLLED TRIAL). J Musculoskelet Res. 2015:1550002.
28. Engebretsen K, Grotle M, Bautz-Holter E, Sandvik L, Juel NG, Ekeberg OM, et al. Radial extracorporeal shockwave treatment compared with supervised exercises in patients with subacromial pain syndrome: single blind randomised study. Bmj. 2009;339.
29. Flores DF, Gentil P, Brown LE, Pinto RS, Carregaro RL, Bottaro M. Dissociated time course of recovery between genders after resistance exercise. J Strength Cond Res. 2011;25(11):3039-44.
30. Cools AM, Witvrouw EE, Declercq GA, Vanderstraeten GG, Cambier DC. Evaluation of isokinetic force production andassociated muscle activity in the scapular rotators during a protraction-retraction movement in overhead athletes with impingement symptoms. Br J Sports Med. 2004;38(1):64-8.
31. Cools AM, Witvrouw EE, Mahieu NN, Danneels LA.Isokinetic scapular muscle performance in overhead athletes with and without impingement symptoms. J Athl Train. 2005;40(2):104.
32. Cools AM, Declercq GA, Cambier DC, Mahieu NN, Witvrouw EE. Trapezius activity and intramuscular balance during isokinetic exercise in overhead athletes with impingement symptoms. Scand J Med Sci Sports. 2007;17(1):25-33.
33. Mottram S. Dynamic stability of the scapula. Man Ther. 1997;2(3):123-31.
34. Atalar H, Yilmaz C, Polat O, Selek H, Uras I, Yanik B. Restricted scapular mobility during arm abduction: implications for impingement syndrome. Acta Orthop Belg. 2009;75(1):19.
35. Cools AM, Dewitte V, Lanszweert F, Notebaert D, Roets A, Soetens B, et al. Rehabilitation of Scapular Muscle Balance Which Exercises to Prescribe? Am J Sports Med. 2007;35(10):1744-51.
36. Youdas JW, Arend DB, Exstrom JM, Helmus TJ, Rozeboom JD, Hollman JH. Comparison of muscle activation levels during arm abduction in the plane of the scapula vs. proprioceptive neuromuscular facilitation upper extremity patterns. J Strength Cond Res. 2012;26(4):1058-65.
37. McClure PW, Bialker J, Neff N, Williams G, Karduna A. Shoulder function and 3-dimensional kinematics in people with shoulder impingement syndrome before and after a 6-week exercise program. Phys Ther. 2004;84(9):832-48.
38. Townsend H, Jobe FW, Pink M, Perry J. Electromyographic analysis of the glenohumeral muscles during a baseball rehabilitation program. Am J Sports Med. 1991;19(3):264-72.
39. Moseley JB, Jobe FW, Pink M, Perry J, Tibone J. EMG analysis of the scapular muscles during a shoulder rehabilitation program. Am J Sports Med. 1992;20(2):128-34.
40. Green S, Buchbinder R, Glazier R, Forbes A. Systematic review of randomised controlled trials of interventions for painful shoulder: selection criteria, outcome assessment, and efficacy. Bmj. 1998; 316(7128):354-60.
41. Colado JC, García-Massó X, Pellicer M, Alakhdar Y, Benavent J, Cabeza-Ruiz R. A comparison of elastic tubing and isotonic resistance exercises. Int J Sports Med. 2010;31(11): 810-7.
42. Colado JC, Triplett NT. Effects of a short-term resistance program using elastic bands versus weight machines for sedentary middle-aged women. J Strength Cond Res. 2008;22(5):1441-8.
43. Andersen LL, Andersen CH, Zebis MK, Nielsen PK, Søgaard K, Sjøgaard G. Effect of physical training on function of chronically painful muscles: a randomized controlled trial. J Appl Physiol. 2008;105(6):1796-801.
44. Faber E, Kuiper JI, Burdorf A, Miedema HS, Verhaar JA. Treatment of impingement syndrome: asystematic review of the effects on functional limitations and return to work. J Occup Rehabil. 2006;16(1):6-24.
45. Grant HJ, Arthur A, Pichora DR.Evaluation of interventions for rotator cuff pathology: a systematic review. J Hand Ther. 2004;17(2):274-99.
46. Walther M, Werne A, Stahlschmidt T, Woelfel R,

Gohlke F. The subacromial impingement syndromeof the shoulder treated by conventional physiotherapy, self-training, and a shoulder brace: results of a prospective, randomized study. J Shoulder Elbow Surg. 2004;13(4):417-23.
47. Medicine ACoS. ACSM's guidelines for exercise testing and prescription: Lippincott Williams & Wilkins; 2013.
48. Melnick M. Therapeutic Exercise: Moving Toward Function. J Phys Ther Educ. 1999;13(2):56.