The most effective exercise for strengthening the supraspinatus

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Introduction

Strengthening the rotator cuff, especially the supraspinatus, is one of the most integral parts of a rehabilitation program for overhead athletes with shoulder problems. Jobe and Moynes [1] suggested that the abduction in the scapular plane with internal rotation, so-called ‘empty can’, is the optimal position to isolate the supraspinatus for strengthening and manual muscle testing. However, Blackburn et al. [2] reported that the prone position, with the elbow extended and the shoulder abducted to 100° and externally rotated, produced greatest EMG activity in the supraspinatus. Recently, Kelly et al. [3] reported that there was no significant difference in supraspinatus muscle EMG activation between abduction in the scapular plane with internal and external rotation. These discrepant results are due to several factors, such as characteristics of the subjects, testing procedure, and EMG analysis. Another possible reason is the relatively poor reproducibility of intramuscular dual silver wire EMG [3, 4], which enables detection of only a small number of muscle fibers, and sometimes an electrode migrates during exercise.

Recently, changes in T2 relaxation time (T2) for muscles observed using MRI after exercise have been shown to be good indicators of muscle recruitment [5, 6, 7, 8]. In other words, an increase in T2 can indicate how much the muscle had been used in the exercise. The purpose of this study was to determine the most effective exercise for the supraspinatus by using MRI to measure T2 for the rotator cuff and deltoid muscles before and after three types of exercise.

Materials and Methods

Six males without shoulder problems volunteered to participate in this study. Their age, height, and weight averaged 25.8 years (range, 25-29), 167.0 cm (range, 161 – 180), and 65.8 kg (range, 62-72), respectively. The subjects performed the following three types of exercise: ‘empty can’ exercise (abduction to 90° in the scapular plane with internal rotation), ‘full can’ exercise (abduction to 90° in scapular plane with external rotation), and ‘horizontal abduction’ exercise (horizontal abduction to 100° in the prone position with external rotation). A wrist weight of 20 repetitive maximum (20 RM) was used for each exercise. The weight of 20 RM was determined at least one week before the MRI examination. Three sets of each exercise with two minutes rest, each set consisting of 15 repetitions, were performed. The exercises were performed at the MR imaging facility so that the subjects could be imaged immediately after exercise. Three types of exercise and MRI examinations were performed at one-week intervals, and the order of the exercise type was randomized. Subjects were imaged before and immediately after the exercise. Oblique sagittal MR images were acquired with a 1.0-T MR imager (Shimadzu, Kyoto, JAPAN) using a dedicated shoulder extremity coil. Two T2-weighted images (repetition time, 2,000 ms; echo time, 20 and 90 ms) were obtained. Images for T2 calculation were created from these two T2-weighted images. T2 values before and after exercise were calculated in a region of interest (ROI, 42 mm2) within muscles. Each ROI was selected so that visible blood vessels and fat were avoided. Two or three ROIs were selected for each muscle. T2 value were calculated for the subscapularis, supraspinatus, infraspinatus, teres minor, anterior, middle, posterior deltoid muscles before and after each exercise. Statistical analysis of the data was performed by one-factor ANOVA (p<0.05) and Post-hoc test (Tukey-Kramer).

Results

After the empty can exercise, the supraspinatus showed the largest increase in T2 among the shoulder muscles, and the increase in T2 for the supraspinatus (10.5 ms) was significantly greater than the increase in T2 for the subscapularis (2.0 ms), teres minor (1.9 ms), anterior (5.2 ms) and posterior (4.3 ms) deltoid muscles. The supraspinatus also showed the largest increase in T2 after the full can exercise. The increase in T2 for the supraspinatus (10.5 ms) was significantly larger than those for the subscapularis (0.4 ms), teres minor (0.9 ms), and posterior deltoid (0.1 ms) muscles.

On the other hand, after the horizontal abduction exercise, the increase in T2 for the supraspinatus (3.6 ms) was significantly smaller than that for the posterior deltoid muscle (11.5 ms) and was not significantly different from the values for the other muscles.

The T2 values for the supraspinatus after the empty can and full can exercises significantly increased compared with that after the horizontal abduction exercise (Fig. 1). There was no significant difference between the values for all muscles except the posterior deltoid muscle in the empty can and full can exercises.

Discussion

It is difficult to compare absolute EMG values between subjects, between muscles, or between test sessions [3]. Therefore, normalization of the EMG signal, such as %MVC, has been used for comparing EMG values. The advantage of using MRI is that absolute values of T2 can be compared between subjects, muscles, and test sessions. The results of the present study demonstrated that T2 increases for the supraspinatus after the empty can and full can exercises were significantly greater than that after the horizontal abduction exercise, suggesting that the empty and full can exercises are more effective for strengthening the supraspinatus than the horizontal abduction. Using open-type MRI, we investigated the position of the supraspinatus during elevation in those exercises, and we found that the empty can and full can exercises are able to place the supraspinatus in the plane of arm-movement, while horizontal abduction places the infraspinatus in the arm-movement plane. Therefore, empty and full can exercises are more effective for applying a load to the supraspinatus than the horizontal abduction.

We found no significant differences in loading of the supraspinatus between the empty can and full can exercises. However, as several authors have pointed out [3, 8], empty can exercise has a risk for provoking pain due to the subacromial impingement. Therefore, full can exercise should be used for rehabilitation, since it involves less risk of pain provocation due to subacromial impingement.

Reference