Effects of rotator cuff muscle training

～ pre-exercise vs post-exercise, baseline vs one month of training ～

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Abstract

This study aimed to investigate the effects of immediate and periodic low-intensity RCM (rotator cuff muscle) training on the IR (internal rotation) torque of the shoulder. Twenty-six healthy men with no previous shoulder injuries were divided into training (n=13) and control (n=13) groups. In both groups, IR torque were significantly decreased in six positions by the single RCM training ($p<0.05$). After the one-month training, the IR torque significantly increased at all positions in the training group ($p<0.01$).

Introduction

Low-intensity internal/external rotation leads to adequate activation of the RCM (rotator cuff muscle)[1)]. RCM training may be beneficial for throwers during their pre-throwing routine[2)]. The effects of RCM training are still unclear[3-7)]. This study aimed to investigate the effects of immediate and periodic low-intensity RCM training on the IR (internal rotation) torque of the shoulder.

Subject & Method

The experimental procedures are summarized in Figure 1. Informed consent was obtained from all subjects. Twenty-six healthy men with no previous shoulder injuries were randomly and equally divided into training (n=13) and control (n=13) groups. First, we measured the isometric IR torque for 3 seconds using isokinetic dynamometer (Biodex system 4, SAKAI Medical) in the dominant shoulders of all subjects (n=26) (Ba-pre (Baseline-pre)). Isometric IR in a seated position with the elbow flexed at 90° were measured in these eight positions randomized: 90° of shoulder abduction ((1)90° ER (external rotation), (2)60° ER, (3)30° ER, (4)0° ER, (5)30° IR) and 0° of shoulder abduction ((6)30° ER, (7)0° ER, (8) 30° IR). Muscle activation was assessed in the clavicular portion of the PM (pectoralis major), latissimus dorsi, and anterior

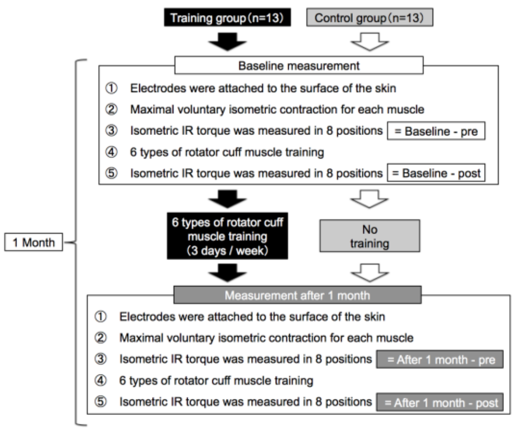

Figure 1. Experimental procedures

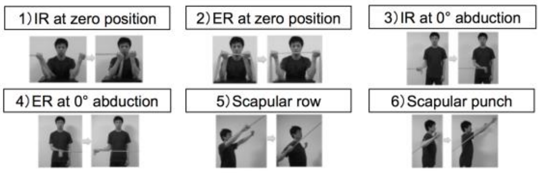

Figure 2. Six types of RCM training

deltoid by surface EMG (electromyogram) (MQ Air, KISSEI COMTEC). The surface EMG was attached in line with the muscle fibers, with an interelectrode distance of approximately 2.0 cm. The subjects rested for a minimum of 2 minutes between trials. Ten minutes after finishing all measurements, six types of RCM training protocols were performed (Figure 2): 1) IR at zero position, 2) ER at zero position, 3) IR at 0° abduction, 4) ER at 0° abduction, 5) Scapular row, 6) Scapular punch. These are commonly introduced in training textbooks and are often practiced for baseball player. We provided a 2 minutes rest period between exercises to control for any fatigue effect. The subjects performed 1 set each of the six types of RCM training protocols, and the elastic band (THERABAND-yellow, SAKAI Medical) loads were described as "feeling fatigued deep in the shoulder". After every RCM training was completed, we measured the isometric IR torque in eight positions for all the subjects (Ba-post (Baseline-post)). After the baseline measurements, subjects in the training group performed six types of RCM training 3 days per week for 1 month. In both groups, we measured the isometric IR torque in eight positions after one month (Af-pre (After 1 month-pre)). After the isometric IR torque was measured in the eight positions, six types of RCM training protocols and isometric IR torque measurements were performed; these measurements were recorded using a process similar to that used for recording the baseline measurements (Af-post (After 1 month-post)). We calculated mean IR torque and integrated EMG data for 250 ms before and after the maximum IR torque at each position (total of 500 ms). All muscle activation data were normalized to the mean activation of the 500 ms MVC (maximal voluntary contraction), and the results were expressed as %IEMG. To evaluate the immediate training effect, paired t-test was used to compare differences in Nm and %IEMG data between Ba-pre and Ba-post for all subjects (Baseline-pre vs Baseline-post). To evaluate the immediate training effect after the one-month program, the paired t-test was used to compare the differences between the Af-pre and Af-post values in the training group (After 1 month-pre vs After 1 month-post). Furthermore, to evaluate the periodic training effect after the one-month program, paired t-test was used to compare differences in Nm and %IEMG data between Ba-pre and Af-pre in both groups (Baseline-pre vs After 1 month-pre). The level of significance used was $p < 0.05$. Statistical analysis were performed using the SPSS version 19.0 (IBM) software.

Results

Mean IR torque and %IEMG comparisons between Ba-pre and Ba-post measurements for all subjects are shown in Table 1 and Figure 3. In both groups, IR torque were significantly decreased in six positions: at 90° of shoulder abduction ((1)90° ER, (2)60° ER, (3)30° ER, (4)0° ER) and 0° of shoulder abduction ((6)30° ER, (8)30° IR) ($p < 0.05$). There was no change in the outer muscle activation at all positions. In the training group after the ome-month training, mean IR torque comparisons between Af-pre and

Table 1. IR torque comparisons between baseline-pre and post measurements for all subjects.

		Baseline - pre	Baseline - post
90° of shoulder abduction	90° ER	34.7 ± 8.4	31.9 ± 8.2**
	60° ER	39.5 ± 9.4	35.2 ± 8.5**
	30° ER	35.8 ± 8.8	31.9 ± 7.0**
	0° ER	28.4 ± 6.3	26.0 ± 5.7*
	30° IR	20.2 ± 5.0	18.7 ± 4.9
0° of shoulder abduction	30° ER	40.4 ± 8.5	38.0 ± 8.8**
	0° ER	35.7 ± 7.7	34.4 ± 7.3
	30° IR	26.6 ± 5.2	24.1 ± 4.8**

**: p<0.01 vs. Baseline - pre *: p<0.05 vs. Baseline - pre

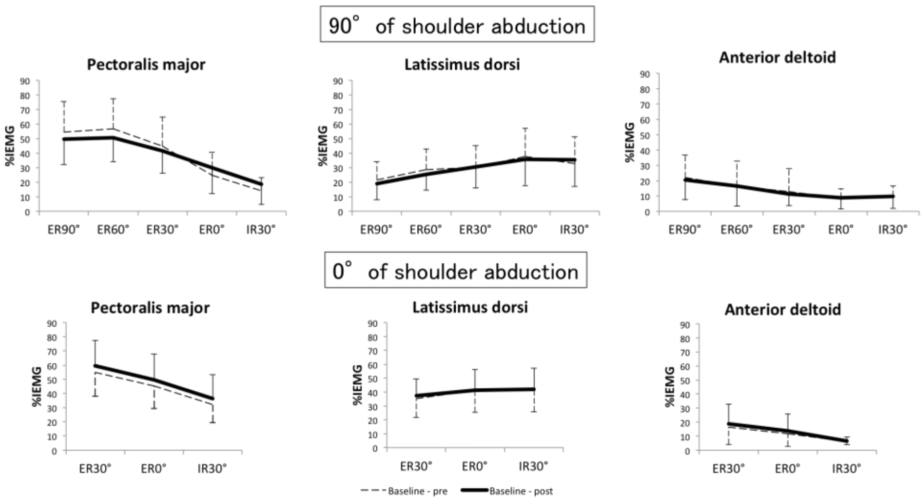

Figure3. EMG activity of each muscle for baseline-pre and post as %IEMG.

Table 2. IR torque comparisons between after 1 month-pre and post measurements in the training group.

		After 1 month - pre	After 1 month - post
90° of shoulder abduction	90° ER	39.5 ± 10.8	35.6 ± 10.8*
	60° ER	42.0 ± 13.4	38.3 ± 14.5**
	30° ER	38.1 ± 11.4	34.8 ± 12.3*
	0° ER	32.4 ± 10.3	28.8 ± 9.2**
	30° IR	25.5 ± 5.5	21.7 ± 6.2**
0° of shoulder abduction	30° ER	43.6 ± 13.4	41.1 ± 14.0**
	0° ER	39.3 ± 12.1	36.4 ± 11.4**
	30° IR	29.7 ± 5.9	25.1 ± 6.1**

**: p<0.01 vs. After 1 month - pre *: p<0.05 vs. After 1 month - pre

Af-post measurements are shown in Table 2. The IR torque of Af-post was significantly decreased at all positions compared with Af-pre. Mean IR torque and %IEMG comparisons

Table 3. IR torque comparisons between baseline-pre and after 1month-pre measurements for both groups.

		Training group (n=13)		Control group (n=13)	
		Baseline - pre	After 1 month - pre	Baseline - pre	After 1 month - pre
90° of shoulder abduction	90° ER	31.3 ± 6.9	39.5 ± 10.8**	38.0 ± 8.7	37.2 ± 7.8
	60° ER	36.9 ± 8.9	42.0 ± 13.4**	42.1 ± 9.6	41.1 ± 7.7
	30° ER	33.6 ± 8.2	38.1 ± 11.4**	38.0 ± 9.1	36.0 ± 8.1
	0° ER	27.0 ± 6.7	32.4 ± 10.3**	29.8 ± 5.8	28.7 ± 5.7
	30° IR	19.2 ± 5.1	25.5 ± 5.5**	21.2 ± 4.9	20.9 ± 5.2
0° of shoulder abduction	30° ER	38.6 ± 8.8	43.6 ± 13.4**	42.1 ± 8.2	41.7 ± 9.4
	0° ER	33.9 ± 6.8	39.2 ± 12.1**	37.4 ± 8.4	37.2 ± 8.5
	30° IR	25.2 ± 5.0	29.7 ± 5.9**	27.9 ± 5.3	28.7 ± 6.3

** : p<0.01 vs. Training group, Baseline - pre

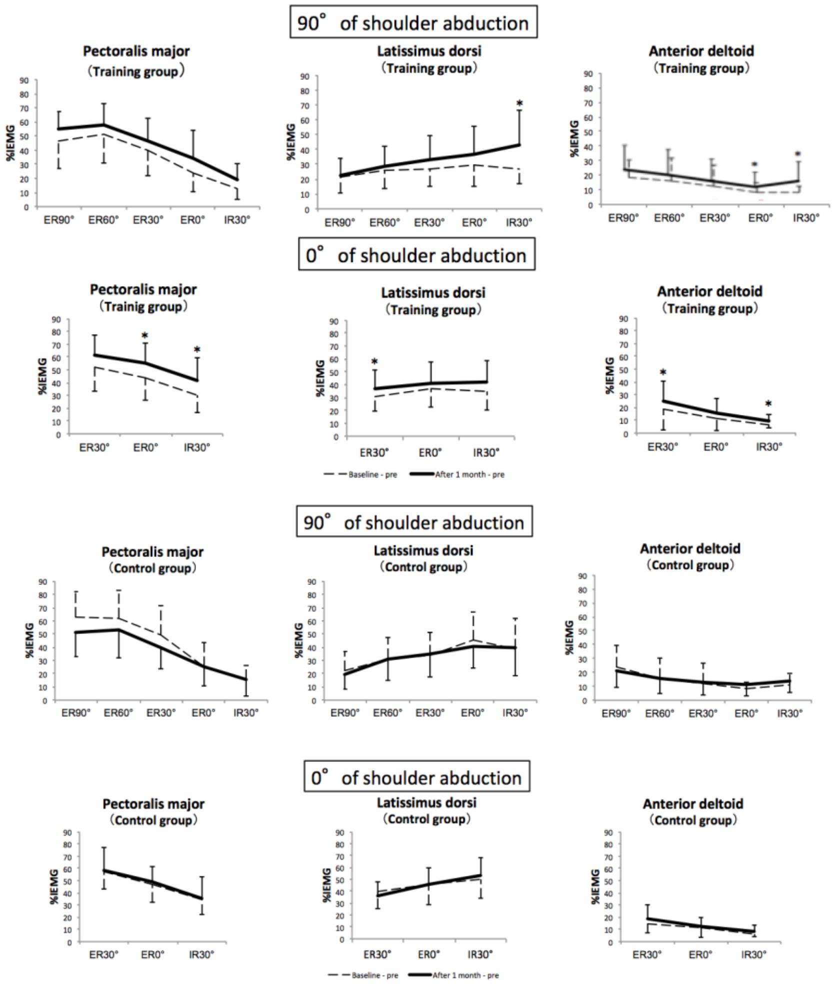

Figure 4. EMG activity of each muscle for baseline-pre and after 1 month-pre as %IEMG.

between Ba-pre and Af-pre measurements for both groups are shown in Table 3 and Figure 4. In the training group, the IR torque of Af-pre was significantly increased at all positions compared with Ba-pre ($p<0.01$). In the control group, there was no change in Af-pre compared with Ba-pre at all positions.

Analysis

The present results showed that RCM training decreased the IR torque immediately in six positions (Table 1). However, there was no change in outer muscle activation for IR torque (PM, latissimus dorsi, anterior deltoid) at all positions (Figure 3). Because this study used only surface EMG, the inner muscles activation such as subscapularis was not measured. Considering that the outer muscles activation did not change, the inner muscles, including the subscapularis, could be fatigued with RCM training. Therefore, the IR torque might be decreased immediately in six positions. Myers et al. [2] demonstrated by using a combination of surface and fine-wire EMG that resistance tubing exercises exhibited moderate activation (>20% MVC) in each shoulder muscle including RCM. Identically, the RCM training adopted in this study also might be exhibited moderate activation of the shoulder muscles. In the training group after the one-month program, the single RCM training immediately decreased IR torque at all positions (Table 2) . We suggested that even if they perform periodical RCM training, IR torque might be decreased immediately after a single training. The IR torque of the shoulder is significantly correlated with throwing velocity[8] . Hence, the results suggest that these exercises for throwers during their pre-throwing warm-up routine might decrease the throwing velocity in baseball games. In the training group, the isometric IR torque was strengthened by RCM training for 1 month (3 days per week) , regardless of the shoulder joint angle (Table 3) . After RCM training, decrease in the IR torque was caused by fatigue of the inner muscles immediately. However, the periodical RCM training improves the contraction force of the inner muscles (particularly the subscapularis and the infraspinatus), which improves the force couple during IR of the glenohumeral joint. The isometric IR torque might be improved as a result of increased dynamic stability during IR of the shoulder joint while maintaining the humeral head centered in the glenoid fossa. The PM has the largest muscle volume and long muscle fiber length[9] , so it is greatly involved in the exertion of the maximum IR force. However, considering the PM muscle fibers direction, the shear force separating the humeral head from the glenoid fossa increases during IR. Therefore, high-intensity IR training for strengthening the PM could cause instability of the shoulder joint. On the other hand, considering the muscle fibers direction of the subscapularis and infraspinatus, RCM training could increase the compression force of the humeral head to the glenoid fossa during IR. Thus, if you want to strengthen IR torque of the shoulder, not only high-intensity training for the PM but also low-intensity training such as RCM should be selected for the purpose of preventing shoulder joint injuries.

Our study has several limitations. First, study used only surface EMG without intramuscular fine-wire EMG. Therefore, the activities and fatigues of the inner muscle were unknown during and after the RCM training. A second limitation is the subjective loads on the tube during each exercise. It might be beneficial for throwers to change the loads during their pre-throwing routine. Research conducted in the future should focus on comparing the effects of changing the number of sets and exercise intensity or different populations.

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