DIFFERENTIAL PATTERNS OF MUSCLE ACTIVATION IN PATIENTS WITH SYMPTOMATIC AND ASYMPTOMATIC ROTATOR CUFF TEARS

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INTRODUCTION: The most appropriate treatment for patients with large rotator cuff tears remains controversial. Some patients exhibit significant functional deficits with rotator cuff tears, while other patients with similar sized tears have nearly normal, painless function [5,6]. The purpose of this study is to evaluate the differential firing patterns of rotator cuff, peri-scapular, and extrinsic shoulder muscles in normal controls, and in patients with symptomatic and asymptomatic large cuff tears. The primary hypothesis is that there are differences in muscle firing patterns between patients with rotator cuff tears and normal, healthy controls with no rotator cuff tear during functional shoulder movements. The secondary hypothesis is that there are additional differences in firing patterns between patients with symptomatic rotator cuff tears and patients with asymptomatic rotator cuff tears of approximately the same size.

METHODS: Eighteen subjects were evaluated: 6 normal controls, 6 patients with symptomatic rotator cuff tears, and 6 patients with symptomatic rotator cuff tears. IRB approval was obtained prior to the start of this investigation, and informed consent was obtained from all participants. Each subject underwent a thorough shoulder examination and completed three shoulder outcomes questionnaires (Simple Shoulder Test, L’Insalata Questionnaire [3], ASES Shoulder Score Index [4]). The subjects were divided into the appropriate group based upon physical exam findings and questionnaire scoring. Inclusion criteria for the normal subjects required them to have subjectively and objectively normal shoulders as well as a shoulder ultrasound confirming the absence of rotator cuff tendon tears. The asymptomatic patient group had minimal pain (< 3 on the visual analog scale); near complete active ROM (within 5 degrees of the opposite side); and an MRI documented cuff tear involving two tendons. The symptomatic patient group had pain > 3 on the visual analog scale; decreased active or passive ROM (> 5 degrees difference compared to the opposite side); functional weakness; and an MRI documented cuff tear involving two tendons.

Surface adhesive electrodes were placed on the three heads of the deltoid; the three portions of the trapezius muscle; the pectoralis major; the latissimus dorsi; and the serratus anterior. Indwelling wire electrodes were placed in the supraspinatus, infraspinatus, and subscapularis muscles. Three-dimensional motion analysis data was collected simultaneously with the EMG data, using an integrated, 60 Hz, 6 camera set up. Prior to data collection, twelve normalization isometric contractions were performed to define the maximal electrical activation in each of the muscles tested [1,2]. All subsequent data was expressed as a percentage of the MVC. Subjects were then asked to perform 10 functional tasks while EMG and kinematic data were collected simultaneously (internal rotation tasks, shoulder elevation tasks, a carrying task, and throwing tasks). Each task was performed 3 times.

RESULT ESSENTIALS: Ultrasound examinations of the normal patients confirmed the absence of rotator cuff tears in all subjects. MRI exams of the patients with symptomatic and asymptomatic rotator cuff tears demonstrated comparable tear patterns in both groups involving both the supraspinatus and infraspinatus tendons. Results of the subjective shoulder scoring questionnaires demonstrated significant differences between all three groups for the L’Insalata and Shoulder Score Index (p < 0.05). For the Simple Shoulder Test symptomatic patients scored significantly lower than the other two groups (p < 0.05). There was no difference between asymptomatics and normals.

EMG data demonstrated a trend toward increased muscle activation in both asymptomatic and symptomatic patients compared to normals. During the internal rotation tasks, (reaching behind the back on the ipsilateral side), asymptomatic patients had significantly greater (p < 0.05) subscapularis activity than symptomatic patients (65% MVC versus 42% MVC) – Fig. 1. During the carrying task, (carrying a 20 lb weight with the involved arm hanging at the side), asymptomatic patients demonstrated significantly less (p < 0.03) upper trapezius muscle activation than the symptomatic patients (16% MVC versus 50% MVC) – Fig. 2. During shoulder elevation tasks, asymptomatics demonstrated significantly greater supraspinatus (p < 0.03), infraspinatus (p < 0.05), and upper trapezius (p < 0.04) muscle activation compared to asymptomatics. During heavy elevation (8 lbs.), asymptomatics showed a trend toward increased activation (p < 0.06) of the subscapularis compared to asymptomatics (34% MVC versus 21% MVC).

DISCUSSION: The three subjective questionnaires that were used in this study accurately reflected differences between groups observed on physical examination and during EMG and kinematic testing. The findings in this study support our primary hypothesis, as we demonstrated that patients with cuff tears (whether they were symptomatic or asymptomatic) had a trend toward increased EMG activity during the functional shoulder tasks tested. The secondary hypothesis was also supported, as we demonstrated statistically significant differences in shoulder muscle firing patterns between symptomatic and asymptomatic cuff tear patients. These differences were observed during internal rotation, carrying, and elevation tasks. During reaching tasks behind the back, asymptomatic patients had greater activation of their subscapularis muscle compared to symptomatic patients. This finding supports the conclusion that symptomatic patients fail to fire their intact subscapularis appropriately during this maneuver. During the carrying task, symptomatic patients had greater activation of their upper trapezius muscle compared to asymptomatic patients. This exaggerated firing of their upper trapezius appears to be necessary for the symptomatic patients to counter heavy loads applied to the shoulder. During shoulder elevation with 8 lbs., asymptomatic subjects demonstrated a trend toward increased activation of their subscapularis compared to symptomatic patients. This finding suggests that symptomatic patients fail to as effectively use their intact subscapularis muscle as a co-contractor during heavy elevation maneuvers. Symptomatic patients demonstrated greater activation of their subscapularis, infraspinatus, and supraspinatus (p < 0.05) shoulder elevation compared to asymptomatics. Based upon this finding, we conclude that symptomatic patients continue to paradoxically fire torn rotator cuff tendons and are forced to rely on peri-scapular muscle substitution (shoulder shrug) during elevation maneuvers which results in compromised function.

To summarize, the findings in this study: (1) the three subjective questionnaires used in this study accurately reflect differences between symptomatic and asymptomatic patients with large rotator cuff tears; (2) patients with rotator cuff tears have a trend toward increased muscle activation compared to normal controls. When compared to asymptomatic patients, symptomatic patients have: (3) paradoxical increased firing of their torn rotator cuff muscles; (4) lack of adaptive firing of their intact subscapularis; (5) and exaggerated firing of their upper trapezius muscle when counteracting downward loads. Our data suggest that patients with large cuff tears may benefit from a program with increased focus on subscapularis rather than supraspinatus and infraspinatus strengthening.