INTRODUCTION:
Surgeons may allow patients to begin gentle passive motion, like pendulum exercises, within a day of rotator cuff repair, but early active motion is usually limited to prevent re-tearing. The goal of our study was to measure the EMG activity of the supraspinatus when a subject performs pendulum exercises correctly (using trunk motion to cause the arm to move, or passively) versus incorrectly (using shoulder musculature to cause the arm to move, or actively), and with three activities of daily living (ADLs): typing, brushing teeth, and drinking from a water bottle. There were two testable hypotheses: (1) performing pendulums incorrectly will elicit more muscle activity than performing pendulum exercises correctly, and (2) pendulum exercises and the chosen light activities will not elicit more than 15% maximum voluntary contraction (MVC) in the shoulder muscles studied.

METHODS:
IRB approval was obtained from our institution, and all subjects signed an informed consent document. Inclusion criteria were: right-hand dominant, age 18 or older, and otherwise healthy. Exclusion criteria included: any history of shoulder pain, injury, or surgery; left-hand dominance; use of an assistive device for ambulation; and inability to tolerate the procedure. Thirteen subjects (seven males, six females) with an average age of 29 (range: 20-57) were included.

Wire electrodes were placed for EMG monitoring of the supraspinatus and infraspinatus. Surface electrodes were placed to monitor the deltoid. Data were recorded at 1000Hz on a Noraxon Myosystem 2000 EMG system (Noraxon, Inc., Scottsdale, AZ) and collected on a personal computer using MotionMonitor software (Innovative Sports Training, Inc., Chicago, IL). Signal processing involved full-wave rectification followed by a two-pass fourth-order low-pass Butterworth filter having a cutoff frequency of 3 Hz. Two dependent measures were computed for each muscle for each trial: mean normalized EMG and maximum normalized EMG. Normalization was done by dividing the acquired signal of a muscle by the maximum EMG recorded during the experiment for that muscle.

The subject was first placed in a standard sling only to complete the three ADLs in a randomized order. Subjects were then instructed in how to perform pendulum exercises. Motion tracking was performed using the Optotrak Certus Motion Capture System (Northern Digital, Inc., Waterloo, ON) and MotionMonitor software. A diagram with 4-inch wide concentric circles of large (average 20 inches) and small (average 8 inches) diameters was placed on the floor to use as a guide. The subject performed the four types of pendulum exercises (large incorrect, large correct, small incorrect, small correct) in a randomized order. The diameter of the pendulum was assured by taping a laser pointer to the dorsal surface of the subject’s wrist. It was emphasized to the subject during the correct exercises that it was more important for the exercise to be passive than for the laser pointer to remain perfectly within the concentric circle diagram. Instruction compliance was verified after each trial with MotionMonitor.

Supraspinatus muscle force was estimated as the product of MVC EMG (between 0 and 1), muscle cross-sectional area (3.36 cm²), specific tension (62 N/cm²), and cosine of the fiber pennation angle (7.0°).

A power analysis was performed based on data collected in a pilot study of three subjects. It was determined that 12 subjects would be sufficient to provide 80% power when controlling the Type I error at 0.05 using a two-sided test. Differences between variables were assessed using the Wilcoxon Signed Rank Test. Statistical significance was set at p < 0.05.

RESULTS:
Three activities (large correct pendulums, large incorrect pendulums, and drinking) showed a mean peak %MVC greater than 15% in the supraspinatus and infraspinatus (Figure 1). Two of these activities (large incorrect pendulums and drinking) exceeded 20% MVC in the infraspinatus.

The difference in %MVC between incorrect and correct pendulum exercises reached statistical significance (p < 0.05) for large diameter pendulums but not for small diameter pendulums. The difference in %MVC for large versus small pendulums was significant (p < 0.05) for both correct and incorrect pendulums.

Estimated mean peak force across the supraspinatus was calculated as 45 N for large incorrect pendulums, 33 N for large correct pendulums, and 51 N for drinking.

DISCUSSION:
If a patient is going to perform pendulums without supervision, then it is imperative that s/he be able to understand and remember to do the exercises in a passive way, preferably in small circles (approximately 8 inches in diameter). Certainly there are some patients who will lack the ability to perform pendulum exercises as prescribed, and supervised or assisted range-of-motion exercises may be safer for these individuals.

Furthermore, patients also need specific instructions (restrictions) post-operatively for ADLs. Even though the patient is able to perform a task (such as drinking from a bottle of water or possibly brushing their teeth) while the operative arm is in a sling, the activity may not be safe. Those patients who wish to return to typing in the early phase after rotator cuff repair can probably do so without placing excess strain on the repair.

REFERENCES:

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