

Electromyographical Comparison of Open and Closed Chain Shoulder Exercises  
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**Objective:** Previous authors have suggested that closed chain shoulder exercises are less demanding than open chain exercises. However, limited scientific information exists to support this theory. The purpose of this study was to determine the difference between electromyographical (EMG) activity of glenohumeral musculature while performing open and closed chain shoulder rehabilitation exercises.

**Design and Setting:** A 3 within factor (position, exercise, muscle) repeated measures ANOVA was performed to compare differences between positions (vertical, diagonal); exercise (open, closed); and muscle (supraspinatus, infraspinatus, anterior deltoid, posterior deltoid, pectoralis major). A Tukey's post hoc analysis was performed on significant ANOVA findings with accepted Alpha level ( $p \leq 0.05$ ).

**Subjects:** Nineteen subjects with normal shoulder function volunteered to participate in this study (age =  $22 \pm 3$  years; ht =  $168.34 \pm 24.74$ cm; wt =  $74.09 \pm 14.99$ kg).

**Measurements:** Bipolar surface electrodes monitored EMG activity of the infraspinatus, pectoralis major, and the anterior and posterior deltoids. A bipolar fine-wire indwelling electrode monitored the supraspinatus EMG activity. All EMG data was normalized to a maximal isometric voluntary contraction (MVIC). Subjects performed 8 trials of vertical shoulder flexion in the plane of the scapula. This was repeated in a  $45^\circ$ -movement plane. Open and closed chain exercises were performed for both positions. The order of exercise was counterbalanced to prevent fatigue and bias. Speed of exercise movement was controlled using a metronome, so that all subjects perform each exercise at  $100^\circ$ /sec. Total EMG activity of the exercise movement was determined as a percentage of MVIC. Three clean trial percentages of total EMG activity were used for statistical analysis.

**Results:** A significant main effect was found for position { $F(1,18) = 24.4$ ,  $p < 0.0005$ } demonstrating that percentage of EMG activity during diagonal ( $12.4 \pm 4.7$ ) was greater than vertical ( $9.9 \pm 4.1$ ) plane movement. A significant main effect was found for exercise { $F(1,18) = 18.7$ ,  $p < 0.0005$ } demonstrating closed chain ( $10.1 \pm 4.5$ ) produced less EMG activity than open chain ( $12.2 \pm 5.0$ ) exercise. A significant interaction was found between muscle and exercise { $F(4,72) = 4.4$ ,  $p = 0.003$ }. Tukey's post-hoc analysis revealed supraspinatus activity was significantly greater in open chain ( $19.0 \pm 2.5$ ) than closed chain exercises ( $14.9 \pm 2.9$ ).

**Conclusions:** This study supports the theory that closed chain exercises performed in this study were less demanding on glenohumeral musculature than open chain exercises. This should be taken into consideration in designing a progressive shoulder rehabilitation program. The differences found between vertical and diagonal shoulder flexion exercises can be explained by changing from a short-lever to long-lever arm activity, respectively. This supports traditional shoulder rehabilitation theory.