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Shoulder muscle activity and function in common shoulder rehabilitation exercises.

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Source

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Abstract

The rotator cuff performs multiple functions during shoulder exercises, including glenohumeral abduction, external rotation (ER) and internal rotation (IR). The rotator cuff also stabilizes the glenohumeral joint and controls humeral head translations. The infraspinatus and subscapularis have significant roles in scapular plane abduction (scaption), generating forces that are two to three times greater than supraspinatus force. However, the supraspinatus still remains a more effective shoulder abductor because of its more effective moment arm. Both the deltoids and rotator cuff provide significant abduction torque, with an estimated contribution up to 35-65% by the middle deltoid, 30% by the subscapularis, 25% by the supraspinatus, 10% by the infraspinatus and 2% by the anterior deltoid. During abduction, middle deltoid force has been estimated to be 434 N, followed by 323 N from the anterior deltoid, 283 N from the subscapularis, 205 N from the infraspinatus, and 117 N from the supraspinatus. These forces are generated not only to abduct the shoulder but also to stabilize the joint and neutralize the antagonistic effects of undesirable actions. Relatively high force from the rotator cuff not only helps abduct the shoulder but also neutralizes the superior directed force generated by the deltoids at lower abduction angles. Even though anterior deltoid force is relatively high, its ability to abduct the shoulder is low due to a very small moment arm, especially at low abduction angles. The deltoids are more effective abductors at higher abduction angles while the rotator cuff muscles are more effective abductors at lower abduction angles. During maximum humeral elevation the scapula normally upwardly rotates 45-55 degrees, posterior tilts 20-40 degrees and externally rotates 15-35 degrees. The scapular muscles are important during humeral elevation because they cause these motions, especially the serratus anterior, which contributes to scapular upward rotation, posterior tilt and ER. The serratus anterior also helps stabilize the medial border and inferior angle of the scapular, preventing scapular IR (winging) and anterior tilt. If normal scapular movements are disrupted by abnormal scapular muscle firing patterns, weakness, fatigue, or injury, the shoulder complex functions less efficiency and injury risk increases. Scapula position and humeral rotation can affect injury risk during humeral elevation. Compared with scapular protraction, scapular retraction has been shown to both increase subacromial space width and enhance supraspinatus force production during humeral elevation. Moreover, scapular IR and scapular anterior tilt, both of which decrease subacromial space width and increase impingement risk, are greater when performing scaption with IR ('empty can') compared with scaption with ER ('full can'). There are several exercises in the literature that exhibit high to very high activity from the rotator cuff, deltoids and scapular muscles, such as prone horizontal abduction at 100 degrees abduction with ER, flexion and abduction with ER, 'full can' and 'empty can', D1 and D2 diagonal pattern flexion and extension, ER and IR at 0 degrees and 90 degrees abduction, standing extension from 90-0 degrees , a variety of weight-bearing upper extremity exercises, such as the push-up, standing scapular dynamic hug, forward scapular punch, and rowing type exercises. Supraspinatus activity is similar between 'empty can' and 'full can' exercises, although the 'full can' results in less risk of subacromial impingement. Infraspinatus and subscapularis activity have generally been reported to be higher in the 'full can' compared with the 'empty can', while posterior deltoid activity has been reported to be higher in the 'empty can' than the 'full can'.