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Empty can exercise provokes more pain and has undesirable biomechanics compared with the full can exercise

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Background: The purpose of this investigation was to characterize the scapular position and scapular muscle activation during the empty can (EC) and full can (FC) exercises. The EC exercise has been shown to produce scapular kinematics associated with the mechanism leading to subacromial impingement syndrome (SAIS) but has not been investigated in patients with (SAIS). This investigation will help improve the treatment of patients with SAIS.
Methods: Participants with SAIS (n = 28) performed 5 consecutive repetitions of FC and EC exercises. Scapular and clavicular 3-dimensional positions and scapular muscle activity were measured during each exercise. Pain was measured with the numeric pain rating 11-point scale.
Results: Participants reported greater pain during the EC exercise vs the FC exercise (difference, 1; $P = .003$). During the EC exercise, participants were in greater scapular upward rotation (difference, 3°; $P < .001$), internal rotation (mean difference, 2°; $P = .017$), and clavicular elevation (difference, 3°, $P < .001$) and in less scapular posterior tilt (difference, 2°; $P < .001$). There was greater activity of upper trapezius (difference, 4%, $P = .002$), middle trapezius (difference, 3%; $P < .001$), and serratus anterior (difference, 0.5%; $P = .035$) during ascent, and during the descent of greater upper trapezius (difference, 2%, $P = .005$), and middle trapezius (difference, 1%; $P = .003$), but less activity of the lower trapezius (difference, 1%; $P = .039$).
Conclusions: The EC exercise was associated with more pain and scapular positions that have been reported to decrease the subacromial space. Scapular muscle activity was generally higher with the EC, which may be an attempt to control the impingement-related scapular motion. The FC exercise of elevation is preferred over the EC exercise.

The Virginia Commonwealth University Office of Research Subjects' Protection Investigational Review Board approved this investigation.

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Subacromial impingement syndrome (SAIS) is the most common musculoskeletal shoulder condition. Conservative treatment of this disorder includes the use of therapeutic exercise. Exercise protocols prescribed to improve symptoms of SAIS are designed to address muscle and motion performance impairments and to restore smooth coordinated movement of the shoulder girdle.[5,13,17] Resisted arm elevation in both the concentric and eccentric modes are commonly used exercises.[27]

Arm elevation exercises in the scapular plane against external loads can be performed with the humerus in a position of internal rotation (empty can [EC] exercise) or external rotation (full can [FC] exercise). The EC exercise has been justified as the preferred exercise over the FC in the treatment of patients with SAIS because it is theoretically superior to recruit the supraspinatus muscle. However, multiple studies[9,11,22,26] have shown no significant differences in supraspinatus muscle activity between exercises, indicating no preference for EC over the FC exercise. When the FC and EC exercises have been used for eccentric loading in the treatment of patients with chronic rotator cuff tendinopathy, positive benefits of reduced pain and increase function have been demonstrated.[3,8,10] The EC exercise might increase compressive loading of the rotator cuff due to the changes in the volume of the subacromial space.[19]

Thigpen et al[28] showed that participants without shoulder pain had increased scapular anterior tilt and internal rotation during the EC exercise compared with the FC exercise. These scapular positions are associated with a decrease in the dimensions of the subacromial space.[15,24] If similar scapular kinematic patterns are found in participants with SAIS, then mechanistically, the EC exercise may have deleterious effects and should not be recommended. A reduction in the subacromial space volume may lead to less available space for the rotator cuff tendons contained within the space.[19]

Smooth coordinated scapular motion is partly accomplished by the synchronize activity of the scapular muscles. Characterizing the scapular muscle activity concurrently with scapular kinematics and pain during the arm ascending and descending phases of the EC and FC exercises will enhance the mechanistic understanding of these exercises. Moreover, this knowledge will improve clinical decision-making for the use of the EC and FC exercises for patients with SAIS.

This investigation of the EC and FC exercises compared the 3-dimensional scapular kinematics (scapular and clavicular position), scapular muscle activation, and patient-reported pain during the exercises in patients with SAIS. First, we hypothesized that during the EC exercise, the scapular upward and internal rotation would be greater and posterior tilt would be less compared with the FC exercise during the arm ascending and descending phases of the exercises. Second, we hypothesized the scapular kinematic patterns would be explained by observed differences in scapular muscle activity and pain between the EC and FC exercises, with greater activation of the upper, middle, and lower trapezius as well as the serratus anterior during the EC exercise to control the scapular kinematics that may affect the volume of the subacromial space.

Materials and methods

Participants

This retrospective comparative study recruited 28 patients with a clinical diagnosis of SAIS from local clinics (Table I). Before testing, the study was explained, and participants signed an informed consent approved by the Virginia Commonwealth University Investigational Review Board for the protection of human subjects. Inclusion criteria included shoulder pain, and 3 of 5 positive findings: painful arc, pain, or weakness with resisted external rotation, Neer, Hawkins, and Jobe tests.[20] The positive and negative likelihood ratios for a positive finding on 3 of 5 clinical tests has been reported to be 2.93 and 0.38, indicating a moderate increase in post-test probability of a diagnosis of SAIS.[20] Exclusion criteria included an inability to elevate the involved arm greater than 150° in the scapular plane, 50% limitation of passive shoulder range of motion in more than 2 planes of motion, pain greater than 7 of 10, history of fracture to the shoulder girdle, systemic musculoskeletal disease, shoulder surgery, glenohumeral instability (positive apprehension, relocation or positive sulcus test),[7,25] or a positive findings for a full-thickness rotator cuff tear (positive lag sign, positive drop arm test, or marked weakness with shoulder external rotation).[21,22]

Procedures

Participants underwent a screening examination to determine inclusion and exclusion criteria. Next, the Penn Shoulder Score questionnaire assessing shoulder pain and function was completed.[12] Surface electromyography (sEMG) electrodes and motion analysis sensors were placed on the participants as described below. The participant's arm was then placed at 90° elevation in the plane of the scapula and supported in this position. The participant performed 2 isometric scaption reference contractions; a 1-minute rest period separated the reference contractions. Participants performed 2 bouts of 5 repetitions, 1 in each of the exercise positions. The exercises bouts were performed in a