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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

Table I Participant demographics and characteristics

Variable	Distribution (n = 28)
Age, mean (SD) y	38.7 (13.4)
Mass, mean (SD) kg	82.5 (16.1)
Height, mean (SD) cm	174.8 (9.1)
Body mass index, mean (SD) kg/m^2	26.97 (4.70)
Female gender, No. (%)	10 (35.7)
Dominant arm, No. (%)	18 (64.3)
Penn Shoulder Score (0-100; 100 = no disability), mean (SD)	67.1 (10.5)
Pain (0-30, 30 = no pain)	19.9 (4.6)
Satisfaction subscale (0-10, 10 = fully satisfied)	4.3 (2.8)
Function subscale (0-60, 60 = full function)	42.9 (6.9)

SD, standard deviation.

random order, a 1-minute rest was given between the exercise bouts. Shoulder pain was rated verbally on a numeric pain scale (0 = no pain, 10 = most extreme pain) during each exercise bout. A minimum of a 1-minute rest separated the exercise bouts.

Kinematics

The 3-dimensional kinematics of the scapula, clavicle, and humerus were measured with a 6-degrees-of-freedom electromagnetic tracking motion capture system (Polhemus 3Space Fastrak; Polhemus, Colchester, VT, USA) integrated with Motion Monitor software (Innovative Sports Technologies Inc, Chicago, IL, USA). The scapular upward rotation, posterior tilt, and external rotation, along with clavicular elevation and protraction were measured. Kinematic data were sampled at 30 Hz. Electromagnetic sensors were secured with double-sided tape. Sensors were placed in accordance with the International Society of Biomechanics protocol.[30] Sensors were placed over the posterior aspect of the distal upper arm, the posterior lateral acromion, and the second thoracic vertebra (Fig. 1). A fourth sensor was used for digitization of bony landmarks.

To create local coordinate systems, each bony segment was digitized with participants in quiet standing with their feet a comfortable width apart, their heels aligned, and their elbows at their side. The trunk was defined by digitizing the spinous processes of the C7 and T7 vertebra, suprasternal notch, and the most caudal point of the xiphoid process. The scapula was defined by a point on the medial scapula at the level of the spine (root of the spine), the most inferior point on the inferior angle of the scapula, and the posterolateral acromion process. The clavicle was defined by digitizing the sternal notch and the anterior acromion. The humerus was defined by the lateral and medial humeral epicondyle, and the humeral head center was estimated by moving the arm through various small arcs of motion to define the center by the least-squares method.

After the application of the sensors and the landmark digitizing procedure, participants were asked to raise and lower their arm 5 times in the plane of the scapula at a pace of 3 seconds for the ascent and 3 seconds for the descent. Scapular and clavicular positions were calculated while the arm was in 30°, 60°, and 90° of arm elevation. The error and reliability of the kinematic variables measurements for participants with SAIS were determined for this investigation. The intraclass correlation coefficients ($ICC_{(3,k)}$) for kinematic measurements ranged from 0.55 to 0.95, the standard error of the measure (SEM) from 1.5° to 3.8°, and the minimal detectable change (MDC) from 2.1° to 5.3°.

Electromyography

The sEMG signals were collected from the upper trapezius (UT), lower trapezius (LT), middle trapezius (MT), and serratus anterior (SA). The sEMG was recorded using an 8-channel Bagnoli EMG System (Delsys Inc, Boston, MA, USA) during each arm elevation repetition. Double silver bar electrodes were placed over the UT, MT, LT, and SA in parallel with the muscle fibers (Fig. 1) and held in place with adhesive tape.[6,14,23] The UT electrode was placed lateral to a point midway between the spinous process of T1 vertebra and the acromion process, along a line connecting T1 vertebra and the acromion process. The MT electrode was placed immediately lateral to a point midway between the spinous process of the T3 vertebra and the root of the spine of the scapula. The LT electrode was placed immediately lateral to the midway point between the spinous process of T7 vertebra and the inferior angle of the scapula, along a line contacting the posterior acromion process and T7 vertebra. The SA electrode was placed along the midaxillary line over rib 6 for the lower portion of the SA, with the participant's arm at 90° of elevation in the scapular plane. Manual muscle test was used to confirm that the SA electrode was not placed over the latissimus dorsi. A reference electrode was affixed with adhesive tape on the contralateral olecranon process.

After the electrodes were applied, 2 brief (6-second) isometric reference contractions were performed at 90° of arm elevation in the plane of the scapula to test electrode placement and provide for sEMG normalization values for each muscle. Participants were given a minimum 1-minute rest between the reference contractions. The sEMG signals were collected at 960 Hz, with a 20-Hz to 400-Hz bandpass filter and a 60-Hz notch filter applied during signal processing. The sEMG signals were full-wave rectification, followed by calculation of the average rectified value (ARV), using the trapezoidal approximation method. The ARV for each muscle was calculated during the rest to 30°, 31° to 60°, and 61° to 90° arm elevation intervals for the ascending and descending phases of the exercises. The limits of integration were determined as the time when the arm passed the lower and upper threshold of the arm elevation interval. The ARV was calculated by dividing the sum of the rectified EMG data by the time that the arm moved through the arc of motion.

The sEMG ARVs were normalized to the ARV calculated during the reference contraction for each muscle. For the reference contraction, the limits of integration were determined by first visually identifying the approximate start and end of the contraction, the MatLab (The MathWorks Inc, Natick, MA, USA) code calculated the middle of the contraction from these approximations. The limits of integration were set 1500 ms before and after the middle of the contraction, providing a 3-second analysis window. The ARV for the reference contraction was calculated by dividing the sum of the rectified EMG values by the time duration of the reference contraction (3 seconds). The mean ARV of the 2 reference contractions trials was calculated for each muscle. The normalized ARV for each muscle was calculated for

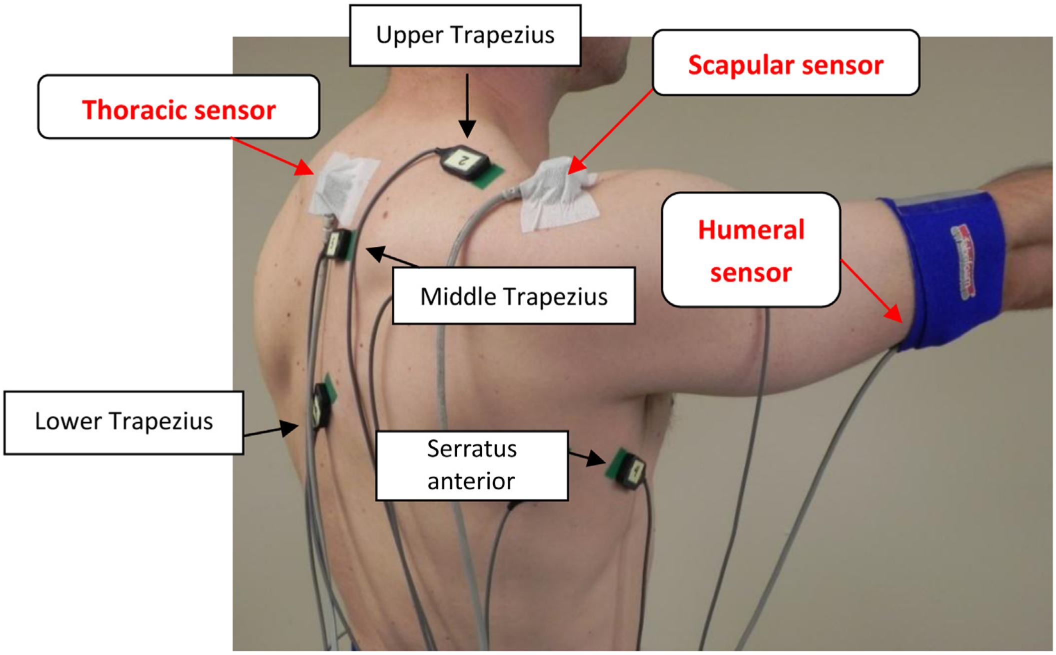

Figure 1 Placement of electromyelography electrodes (named by the muscle) and electromagnetic motion capture sensor (*rounded boxes*).

each of the 3 arm elevation intervals. The error and reliability of the sEMG variable measurements for 9 participants with SAIS were determined for this investigation. The sEMG $ICC_{(3,k)}$ ranged from 0.53 to 0.97, the SEM from 2.5% to 25.1%, and the MDC from 3.6% to 35.4%.

Statistical analysis

Values for each of the dependent variables (kinematic and sEMG) were entered in to a 2 × 3 (exercise position × arm elevation angle) repeated-measure analysis of variance, with a separate analysis performed for the ascending and descending phases of the exercise. The dependent variables mean differences, F statistic along with the corresponding degrees of freedom ($F_{(I,j)}$) and the P values will be presented. Paired t tests with Bonferroni correction ($P < .017$[.05/3]) were used to determine statistical differences between exercise groups when significant interactions were found. Paired t tests were also used to compare pain ratings between exercise groups. Statistical significance was determined a priori at $P < .05$. Data were analyzed using SPSS 19 statistical software (IBM Corp, Armonk, NY, USA).

Results

Participants experienced greater pain (mean difference, 0.9; $t = 3.25$, $P = .003$) during the EC exercise (mean, 4 ± 2) than during the FC exercise (mean, 3 ± 2).

Kinematics

The scapular and clavicular positions (means and standard deviations) during each exercise are presented in Fig. 2. A general pattern of scapular increasing scapular upward rotation and clavicular elevation and decreasing scapular anterior tilt (posterior tilt), and clavicular protraction (clavicular retraction) was seen during the ascending phase. The opposite pattern was found during descent.

There was a significant main effect for exercise position. The scapula was in greater upward rotation during the EC exercise compared with the FC exercise during the ascending (mean difference, 3°; $F_{(1,27)} = 31.95$, $P < .001$) and descending (mean difference, 2°; $F_{(1,27)} = 5.04$, $P = .033$) phases.

The scapula was in a position of internal rotation throughout the ascending and descending phases during the EC and FC exercises. However, the scapula was in greater internal rotation during the EC exercise during the ascending phase (mean difference, 2°; $F_{(1,27)} = 6.52$, $P = .017$). During the descending phase, the scapula followed the opposite pattern of motion. There was not a significant main effect for exercise position ($F_{(1,27)} = 2.18$, $P = .105$) during the descent for scapular internal rotation.

The scapula was in an anterior tilted position throughout the ascending phase but became less anteriorly tilted with increasing arm elevation during both exercises. During arm ascent, there was a significant main effect for exercise position (mean difference, 2°; $F_{(1,27)} = 18.75$, $P < .001$), with greater scapular anterior tilt in the EC position. During the descent, the scapula increased in anterior tilt; however, there was no main effect for exercise position during the descent ($F_{(1,27)} = 1.292$, $P = .266$).

During the ascending phase, the clavicle was in elevation during both the EC and FC exercises. There was a significant exercise position main effect (mean difference,

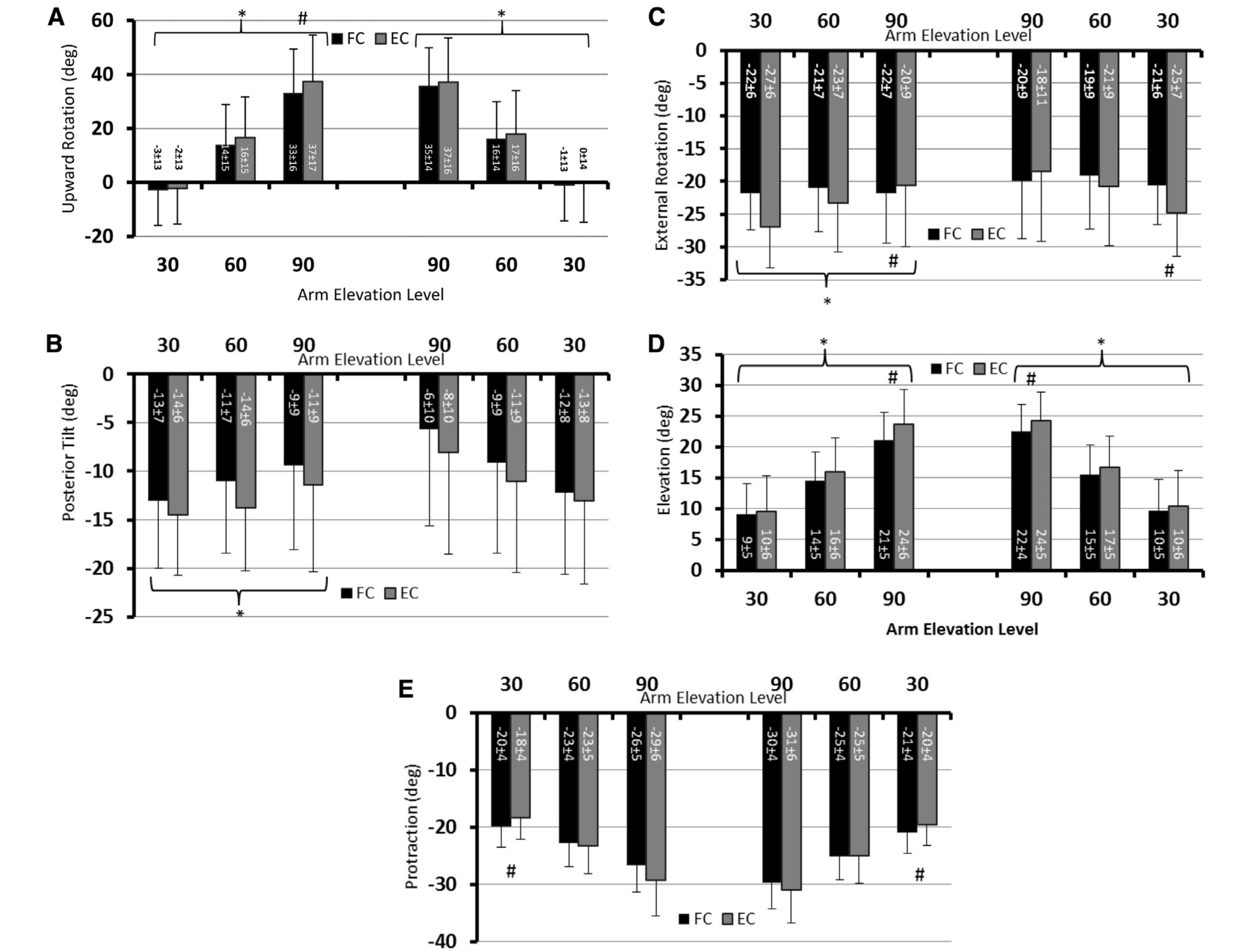

Figure 2 Scapular and clavicular kinematics (mean and standard deviation) during arm elevation in the plane of the scapula during the empty can (*EC*) and full can (*FC*) exercises. (**A**) Scapular upward rotation, (**B**) scapular anterior/posterior tilt, (**C**) scapular external rotation, (**D**) clavicular elevation, and (**E**) clavicular protraction. *$P \leq .05$, exercise group main effect; #$P < .05$ arm elevation angle-by-exercise group interaction.

2°; $F_{(1,27)} = 16.47$, $P < .001$) of greater clavicular elevation in the EC exercise. There was an exercise position–by–arm elevation angle interaction for clavicle elevation ($F_{(2,54)} = 14.55$, $P < .001$), with significantly greater clavicular elevation at the 90° arm elevation (mean difference, 3°; $t = 5.02$, $P < .001$) for the EC exercise. During the descending phase, there was a significant exercise position main effect of greater clavicular elevation during the EC exercise (mean difference, 1°; $F_{(1,27)} = 8.55$, $P = .007$).

During the ascending and descending phases of both exercises, the clavicle remained retracted and moved into greater retraction. A significant main effect was not noted for exercise position during the ascent ($F_{(1,27)} = 1.74$, $P = .197$) and the descent ($F_{(1,27)} = 0.05$, $P = .827$).

There were significant exercise position–by–arm elevation angle interactions during the ascent for scapular upward rotation ($F_{(2,54)} = 20.55$, $P < .001$), internal rotation ($F_{(2,54)} = 33.89$, $P < .001$), and clavicular elevation ($F_{(2,54)} = 14.55$, $P < .001$). During the EC exercise position, the scapula was in greater upward rotation (mean difference, 4°; $t = 7.15$, $P < .001$) and clavicle elevation (mean difference, 2°; $t = 3.42$, $P = .002$) at 90° and greater scapular internal rotation at 30° (mean difference, 4°; $t = 4.26$, $P < .001$).

Muscle activation

Muscle activity (Fig. 3) was generally higher during the EC exercise than during the FC exercise, and muscle activity increased with higher arm elevation angles and decreased with during the descent ($P < .001$ for all muscles).

During ascent, significant exercise position main effects of greater activity were found during the EC exercise for the UT (mean difference, 4 %; $F_{(1,27)} = 11.43$, $P = .002$), MT (mean difference, 3 %; $F_{(1,27)} = 26.18$, $P < .001$), and

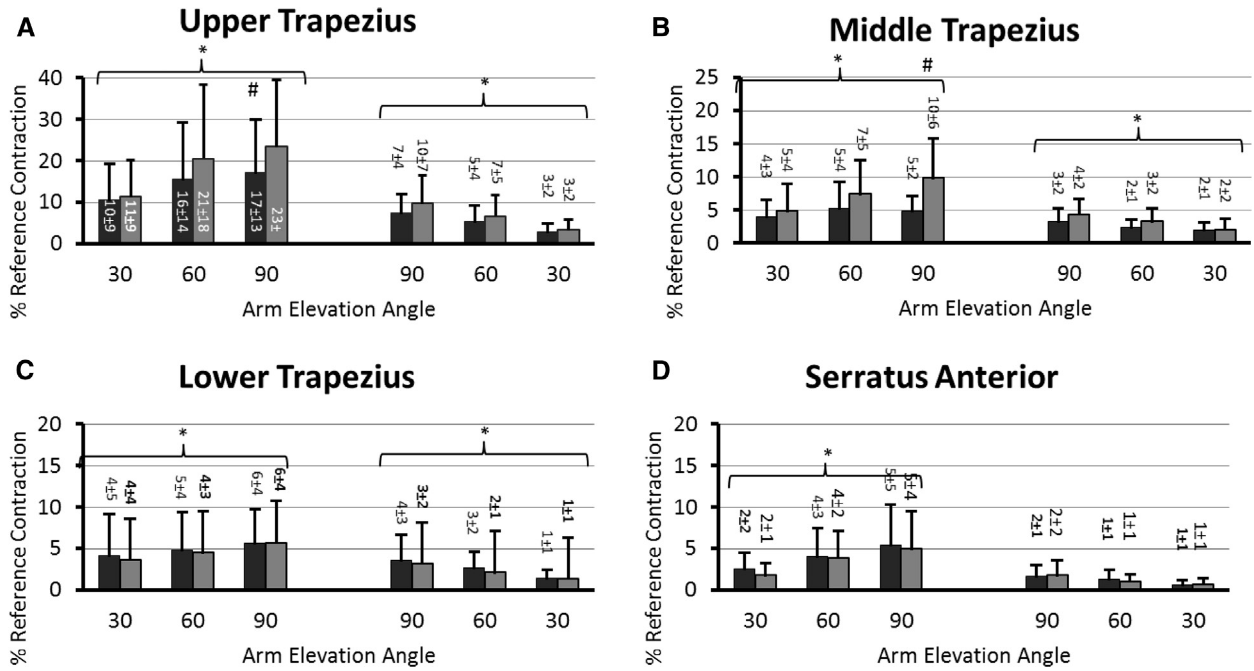

Figure 3 Surface electromyography (mean and standard deviation) during arm elevation of the full can (*solid fill*) and empty can (*shaded fill*) exercises, with muscle activity reported as a percentage of a maximal voluntary isometric reference contraction performed at 90° arm elevation in the plane of the scapula. (**A**) Upper trapezius, (**B**) middle trapezius, (**C**) lower trapezius, and (**D**) serratus anterior. $*P < .05$, exercise group main effect, $\#P < .05$ arm elevation angle-by-exercise group interaction.

SA (mean difference, 1%; $F_{(1,27)} = 4.95$, $P = .035$). There was no exercise position main effect in the ascent phase for the LT ($F_{(1,27)} = 0.26$, $P = .615$). There was a significant interaction during the ascent for the UT ($F_{(2,54)} = 4.99$, $P = .010$), and greater UT activity during the EC position at 90° arm elevation (mean difference, 6%; $t = 3.66$, $P = .001$).

During the descent phase, the EC exercise exhibited greater activity for the UT (mean difference, 2%; $F_{(1,27)} = 9.58$, $P = .005$), greater activity for the MT (mean difference, 1%; $F_{(1,27)} = 10.39$, $P = .003$), and less activity for the LT (mean difference, 1%; $F_{(1,27)} = 4.70$, $P = .039$). During the descent, there were no significant main effects for exercise position for the SA ($F_{(1,27)} = 0.02$, $P = .888$).

There was a significant exercise position by arm elevation angle interaction during the ascent for the UT ($F_{(2,54)} = 4.99$, $P = .010$) and MT ($F_{(2,54)} = 3.34$, $P = .043$). The UT (mean difference, 6%; $t = 3.66$, $P = .001$) and MT (mean difference, 1%; $t = 5.30$, $P < .001$) had greater activity in the EC position at 90°.

Discussion

The current investigation identified differences in the kinematics of the scapula and clavicle along with differences in activation of the scapular muscle during the EC and FC exercises in participants with SAIS. The kinematics differences during the ascending phase of the EC exercise were greater scapular upward rotation, internal rotation, and anterior tilt along with greater clavicular elevation. Fewer kinematic differences were found during the descending phase. The scapula during the descending EC exercise was in greater scapular upward rotation, and the clavicle was in greater elevation. Participants also reported statistically greater pain during the EC exercise; however, the difference was minimal and might not have an important clinical meaning.[18] It is likely that the differences in pain between the exercises did not affect the measured kinematics.

This study furthers the work by Thigpen et al,[28] who reported greater scapular anterior tilt and internal rotation with the EC exercise in participants without shoulder pain and suggested the FC exercise may be the preferred exercise; however, they did not report clavicular kinematics. Thigpen et al[28] found greater scapular anterior tilt and internal rotation with the EC exercise, which agrees with our findings; however, they did not find a difference between the exercises in scapular upward rotation. The small difference we found in UR was less than the MDC for UR, and this finding needs to be interpreted with caution. The kinematic alterations we found during the EC exercise have been associated with a decrease in the dimensions of the subacromial space, which may lead to compression of the rotator cuff tendons and subacromial bursa.[15,24] The kinematic and muscle activity alterations along with greater pain in the EC exercise provides support for clinical use of the FC exercise over the EC exercise for patients with SAIS.

An increase in scapular anterior tilt and internal rotation seen with the EC exercise has been associated with a decrease in the width of the subacromial space, potentially leading to compression of rotator cuff tendon and SAIS.[16,24] We found no differences in scapular internal rotation or anterior tilt during the descending phase of the exercises but did find an increase in scapular upward rotation during the descending phase of the EC exercise. This combination of scapular motions might be a motor control strategy used to maintain the width of the subacromial space or to reduce the shoulder pain experienced during arm elevation in patients with SAIS.

Scapular muscle activity was generally greater during the EC exercise. Specifically, there was increased UT and MT activity during both the ascent and descent, increased SA during ascent, and decreased LT during descent during the EC exercise compared with the FC exercise. These differences likely represent motor control adaptations to attempt to control the potentially deleterious kinematic alterations that may lead to rotator cuff compression and to minimize the increased shoulder pain reported during the EC exercise.[15,24]

Therapeutic exercises typically involve multiple concentric/eccentric cycles, and the participants of the current study preformed 5 consecutive concentric/eccentric cycles while holding the same weight with the arm in the EC and FC exercises. We saw higher muscle activity in the EC exercise. The moment about the shoulder produced by the weight would have been equal in both conditions, yet higher muscle activities were found in the EC exercise. As hypothesized, this increased activity may be in response to the increased pain or in an attempt to control the altered kinematics with the EC exercise. Alternatively, the higher muscle activation might lead to greater overload of the scapular muscles, resulting in enhanced training of these muscles in the EC exercise. The disruption of the force couple between the UT and LT muscles, with greater UT activity not being balanced by an increase in LT activity, is of concern. Contraction of the UT will produce scapular anterior tilt that is theorized to increase SAIS. We found the scapula was in a position of greater anterior tilt during the EC exercise, and participants reported greater pain.

The weight held in the participant's hand applied an external load to the arm. This external load was far from a maximal load, producing muscle activities of less than 10% of an MVIC contraction for the MT, LT, and SA muscle. Muscle activities below 10% MVIC have been shown to be minimal and may not be significant,[1,4] an applied external load that creates muscle activities greater than 10% MVIC might produce differing kinematic patterns.[1,29] The higher muscle activity seen during the EC exercise could also be explained by the novelty of this exercise. This difference might disappear if the patient continued to practice the exercise and learned more efficient muscle activation patterns to elevate the arm in the EC position.

The data for the descending phase demonstrate that the scapular kinematics during the EC exercise do not differ greatly from the FC exercise. There was greater scapular upward rotation and clavicular elevation without any difference in the scapular anterior tilt or internal rotation positions during the descending phase. Scapular upward rotation should increase the width of the subacromial space.[24] This would suggest that the EC exercise might not have deleterious effects in the descending phase. This may have important clinical implications, because the descending phase of the EC and FC exercise is emphasized when eccentric focused exercises are used in the treatment of patients with tendinopathy.

A recent systematic review concluded that eccentric focused exercises could produce promising clinical outcomes in the treatment of tendinopathy of the Achilles and patellar tendons.[2] Unlike the Achilles and patellar tendons, the tendons of the rotator cuff are constrained within the subacromial space. The constraints placed on the rotator cuff by the subacromial space might negatively influence the outcomes of therapeutic exercise programs that focus on eccentric loading rotator cuff by increasing the impingement of the rotator cuff in the subacromial space. The use of eccentric focus of the FC and EC exercises can provide beneficial outcomes.[8,10] Mechanistically, we found the descending phase of the EC exercise resulted in only minimal potentially impingement-producing scapular kinematics. This investigation, along with the recent clinical trial that used the EC exercise with an eccentric focus, suggests the use of the EC exercise for eccentric training. However, whether participants have greater pain during the descent phase in the EC exercise position compared with the FC exercise position is unclear because we did not ask patients to rate pain separately in each phase of the exercise.

This study has some limitations. We did not measure muscle activity of the rotator cuff or several other muscle of the shoulder, which prevents a discussion of the implications for the effects of the FC and EC exercises on the activation of these muscles during the exercises. The greater pain experienced during the EC exercise was less than the reported MDC for the numeric pain scale. Patients with higher reported pain might show greater kinematic and muscle activation difference between the 2 exercises.

The participants of this study performed a bout of 5 repetitions for each exercise. It is possible that if the participants had performed enough repetitions to induce muscular fatigue, we could have seen differing kinematic and muscle activation patterns. However, we wanted to determine the effects changing glenohumeral rotation on scapular position at the start of the excise. That greater external loads would produce differing patterns of kinematic and muscle activation is also likely. Direct measurements of the subacromial space were not taken, so implications of the altered scapular and clavicular kinematics on subacromial space dimensions are limited. Supraspinatus muscle activity was compared between the FC and EC, but further study is needed to examine the muscle activity of the 4 rotator cuff muscles to fully understand the use of these exercises in patients with rotator cuff disorders. Future studies are needed to determine the effects of fatigue-producing bouts of exercise on the scapular kinematics and the relation between the changing kinematic and muscle action patterns and the dimensions of the subacromial space.

Conclusions

This investigation of participants with SAIS found differing scapular kinematic patterns between the EC and FC exercises. The current findings are consistent with the kinematic difference found in participants without shoulder pain, with the exception that we found a suggestion of a small increase in scapular UR during the EC exercise, perhaps representing an attempt to maintain the dimensions of the subacromial space and reduce compression of the rotator cuff tendons. The scapular kinematic patterns seen during the EC exercise are consistent with the kinematic patterns that have been associated with the extrinsic mechanisms producing SAIS, suggesting that the EC exercise should be avoided.

Disclaimer

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