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Original paper

Rotator cuff coactivation ratios in participants with subacromial impingement syndrome

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Abstract

Coactivation of the rotator cuff is vital to glenohumeral joint stability by centralising the humeral head within the glenoid fossa. Yet in individuals with subacromial impingement, it is hypothesised that rotator cuff coactivation abnormalities are present that could contribute to their shoulder pain. The purpose of this study was to determine if abnormal rotator cuff coactivation and deltoid activation patterns exist in participants with subacromial impingement. Rotator cuff (supraspinatus, infraspinatus, and subscapularis) coactivation and middle deltoid activation was assessed during an elevation task. ANOVA models were used to compare muscle activation patterns in 10 participants with subacromial impingement and 10 control participants. Participants with impingement exhibited decreased rotator cuff coactivation (subscapularis–infraspinatus and supraspinatus–infraspinatus) and increased middle deltoid activation at the initiation of elevation (0–30° of humeral elevation). The participants with impingement also had higher subscapularis–infraspinatus and supraspinatus–infraspinatus coactivation above the level of the shoulder where pain is typically present (90–120° of humeral elevation). The results indicate that individuals with subacromial impingement exhibit rotator cuff muscle coactivation and deltoid activation abnormalities during humeral elevation that might contribute to the encroachment of the subacromial structures associated with subacromial impingement.

Keywords: Shoulder; Impingement; Rotator cuff; Coactivation; Electromyography; Injury

1. Introduction

The primary purpose of the rotator cuff muscles is to create compressive forces through coactivation to stabilise the humeral head within the glenoid fossa [8,17,22]. During humeral elevation, compression by the rotator cuff creates a stable fulcrum for the humeral head on the scapula, allowing the deltoid to elevate the arm without superiorly translating the humeral head on the glenoid [13]. But in patients with subacromial impingement, superior translation during humeral elevation has been identified, contributing to the compression of the subacromial structures [4,6,19]. Potentially, poor coactivation by the rotator cuff muscles combined with increased activation by the deltoid could be contributing to this superior humeral migration and ultimately impingement. While activation of each rotator cuff muscle and humeral mover has been assessed in patients with subacromial impingement [14,20], it is the coactivation between the rotator cuff muscles that is most important functionally. To date, coactivation has not been quantified in individuals diagnosed with subacromial impingement. We hypothesise that individuals with subacromial impingement will demonstrate differences in rotator cuff coactivation and deltoid activation compared to individuals with no history of shoulder pain and injury. As such, the purpose of this study is to measure rotator cuff coactivation and middle deltoid muscle activation in participants diagnosed with subacromial impingement syndrome.

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Table 1
Study participant demographics

	Subacromial impingement participants (5 males, 5 females)		Control participants (5 males, 5 females)		t-Test [t(d.f.), p]
	Mean	±S.D.	Mean	±S.D.	
Age (years)	42.70	10.61	36.58	7.61	1.6(18), 0.13
Height (cm)	170.27	10.60	176.22	6.83	−1.6(18), .13
Mass (kg)	73.76	13.68	81.14	17.27	−1.8(18), 0.28
VAS pain level	5.00	1.54			

2. Methods

Twenty participants took part in this study including ten individuals diagnosed with subacromial impingement and ten control participants. Participants with subacromial impingement were recruited by providing information to patients with subacromial impingement seen within our orthopedic clinic. Interested participants contacted the investigators. Subacromial impingement was defined as localised pain lasting longer than 2 weeks in duration on the proximal anterolateral shoulder region, positive impingement signs, including positive Neer, Hawkins, and empty can tests, a painful arc of movement (60–120°), and/or tenderness to palpation in the region of the greater tuberosity or rotator cuff tendons. All diagnoses were made by an orthopedic surgeon and confirmed by lidocaine injection in the subacromial space to verify subacromial impingement. Subsequent follow-up with participant records indicated that nine out of the 10 participants with subacromial impingement eventually opted for subacromial decompression surgical intervention. Ten control group participants were matched with the impingement participants were matched according to gender, age, height, weight, and limb (dominance and involvement). All control participants had no self-reported history of shoulder pain or injury that required medical intervention. Control participants were recruited by posted advertisements. All study participant demographics are shown in Table 1.

Each participant attended one laboratory testing session. Before testing, each participant provided consent as required by the Institutional Review Board. Initially, each participant's maximum humeral elevation torque was recorded isometrically on a dynamometer (Biodex System III Isokinetic Dynamometer, Biodex Medical, Shirley, NY) with the participants seated and their limb positioned at 20° elevation in the scapular plane. Maximal elevation torque was used to calculate the load to be held during subsequent functional elevation tasks. The load held equalled 25% of their maximum elevation torque.

Dual finewire electrodes constructed with 0.05 mm nickel chromium alloy wire insulated with nylon (California Fine Wire Company, Grover Beach, CA) were prepared according to published recommendations [2,11] and inserted intramuscularly through a 1.5-in. 25-gauge needle into the subscapularis, supraspinatus, and infraspinatus. Insertion sites were sanitised using 70% isopropyl alcohol and an iodine solution before insertion. Silver–silver chloride surface electrodes (Medicotest Inc., Rolling Meadows, IL) were used to measure middle deltoid muscle activity. Two surface electrodes were placed side-by-side and perpendicular to the orientation of the muscle fibers with 2 cm separating the center of each electrode. Correct positions of all electrodes were confirmed through isolated manual muscle testing. Electromyographic data were collected with the Noraxon Telemyo (Noraxon, Scottsdale, AZ) electromyography system. Electromyographic signals collected were passed through a single ended amplifier (gain, 500) to an eight-channel FM transmitter. A receiver unit collected the telemetry signals from the transmitter, where the receiver amplified (gain, 500) and hardware filtered (range, 15–500 Hz band pass Butterworth filter; common mode rejection ratio of 130 dB) the signals. Signals from the receiver were then converted from analog to digital data at a rate of 1000 Hz. Additionally, all participants were fitted with electromagnetic receivers (MotionMonitor electromagnetic tracking device (Innovative Sports Training, Inc., Chicago, IL)) that were used for calculation of humeral elevation during the elevation trials [16].

Collection trials consisted of each participant elevating his/her arm in the scapular plane (30° anterior to the frontal plane) from 0° elevation (arm at the side) to maximum elevation and returning to 0° elevation. The participants were seated during the elevation tasks. Through the use of a metronome, each elevation–depression task lasted 4 s (2 s to complete humeral elevation and 2 s to complete humeral depression). Participants were provided with a period of trial practice to until they felt comfortable performing the elevation–depression task with the metronome. For data collection, each participant performed 10 continuous elevation–depression repetitions while holding the previously determined resistance (sandbags). Elevation in the scapular plane was maintained through the use of a guide tube.

To calculate rotator cuff and deltoid muscle activation and rotator cuff coactivation at the desired phases of elevation, humeral elevation relative to the thorax was calculated using recommended Euler angle sequence [23]. The phases of interest studied were 0–30°, 30–60°, 60–90°, and 90–120° humeral elevation (relative to the thorax) in the scapular plane.

All raw EMG data was smoothed by root mean square at a time constant of 50 ms. Mean activation of the supraspinatus, infraspinatus, subscapularis, and middle deltoid were