A META-ANALYSIS OF SCAPULAR KINEMATICS OF PATIENTS WITH AND WITHOUT SUBACROMIAL IMPINGEMENT SYNDROME

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SUMMARY
Inconsistent deficits of three-dimensional (3D) scapular kinematics during arm elevation in patients with subacromial impingement syndrome (SAIS) are reported. The objective of this meta-analysis is to determine if there are consistent differences in 3D scapular kinematics between patients with SAIS and controls during active arm elevation.

A search (Pubmed, Science Direct, Ovid databases) identified 65 studies; 14 studies met the criteria for full-text review. Nine papers met the inclusion criteria for this meta-analysis. Sample sizes, means and standard deviations of scapular upward rotation (UR), external rotation (ER), posterior tilt (PT), clavicular elevation (ELE) and clavicular retraction (RET) variables were extracted from the papers when available or from the lead author when not directly stated in the paper.

The results of this meta-analysis revealed that overall, patients with SAIS displayed less UR and ER, greater ELE and RET and no difference in PT. Compared to controls, SAIS patients had less UR at arm elevation angles (ARM) less than 90° and greater ELE and RET at high (greater than 90°) ARM. The plane of arm elevation (PLANE) influenced scapular kinematics with SAIS. Analysis of population (POP) showed athletes and overhead with SAIS had different scapular kinematic pattern when compared to controls.

INTRODUCTION
Rotator cuff disease is a common shoulder disorder that encompasses the entities of subacromial impingement syndrome, bursitis, tendinosis, tendinopathy and rotator cuff tendon tears. Altered scapular and clavicular kinematics have been demonstrated in patients with rotator cuff disease, specifically SAIS. [1] Hypothetically, a decrease in scapular posterior tilt (PT), external rotation (ER) and upward rotation (UR) reduces the subacromial space volume leading to compression of the rotator cuff tendons.[2] However, a recent literature review by Ludewig and Reynolds [3] revealed inconsistencies in the relationship between SAIS and scapular kinematic patterns. The purpose of this systematic review and meta-analysis is to explore the relationship between SAIS and scapular kinematics. Specifically, we hypothesize that patients with SAIS compared to controls during active arm elevation will have: 1) less scapular UR, 2) less scapular PT, 3) less scapular ER, 4) more clavicular ELE and 5) less clavicular RET.

METHODS
A literature search was conducted in the Medline/Pubmed, Science Direct and Ovid databases for published research prior to March, 2010; the key terms of the search were shoulder, human, kinematics, scapula and SAIS. This database search identified 65 studies. The abstracts of the 65 papers were reviewed by 2 authors to determine if the paper: 1) compared subjects with SAIS to those without SAIS, 2) presented scapular kinematic variables, and 3) was not a review article, 14 studies met these criteria and were subject to a full text review. The full-text of the 14 papers was reviewed by 2 investigators for inclusion criteria: patients with SAIS diagnosed by healthcare professionals, scapular kinematics using ISB recommendation when appropriate and scapular kinematics were measured during open chain arm elevation. Nine papers met the full-text review inclusion criteria and were entered into the meta-analysis. Each paper of the 9 papers was assessed for threats to validity using a 23-point quality assessment tool.

The sample sizes, means and standard deviations of UR, ER, PT, ELE and RET kinematic variables were extracted from each paper or from the paper’s lead author by one investigator. Extracted data was verified by a second investigator. The standard difference in the mean (SDM) was calculated for each outcome. For each variable, we coded the effect as positive or negative. A positive effect was coded as the scapular rotations or positions theorized to be associated with increased risk of SAIS of less PT, less UR, less ER, greater ELE (superior scapular position), and less RET (medial scapular position) as compared to controls. The Z statistic was used to determine if the overall group differences for each kinematic variable was different from zero. The Q statistic was used to determine the heterogeneity of the data. If the Q statistic was significant, indicating heterogeneity, a random-effects model was used. Moderator variables for this analysis were PLANE (frontal, scapular and sagittal), ARM (greater than 90° and less than 90°) and POP (general, overhead workers and athletes).
RESULTS AND DISCUSSION

Quality assessment scores from 2 reviewers had excellent reliability [ICC (3,1) = 0.91; 95%, CI:0.44-0.96]. The mean quality score was 78.0% ±14.0%, range 42.9–90.0%. Study quality was not found to be related to effect size for any of the outcome variables: PT, slope=0.02, p = 0.07; UR, slope = 0.006, p = 0.39; ER, slope = 0.001, p = 0.91; ELE, slope = -0.02, p = 0.31; RET, slope = -0.006, p = 0.79. There was no bias detected for PT (intercept = 1.3, p = 0.75), ER (intercept = 1.94, p = 0.53), or ELE (intercept = 1.25, p = 0.80). The trim and fill confirmed these results with no studies trimmed for these outcomes. Bias was detected for UR (intercept = 4.4, p = 0.06) and RET (intercept = 0.57, p = 0.01). For UR the trim and fill procedure trimmed three studies and yielded a corrected effect size of 0.007. For RET two studies were trimmed yielding a corrected effect size of -0.27, suggesting the bias was minimal. The effects were small for the kinematic variables; UR (effect size = 0.26) and ER (effect size = -0.21), ELE (effect size = 0.31), and RET (effect size=-0.26).

By collapsing the data from prior studies by way of meta-analysis, patients with SAIS as compared to controls displayed an overall effect of less UR (z = 3.08, p = 0.002), less ER (z = 2.33, p = 0.020), greater ELE (z = 3.93, p<0.001), greater RET(z = -4.09, p<0.001) and no difference in PT (z = 1.38, p = 0.17). These results concurred with our hypotheses of less scapular UR and ER, and greater ELE in SAIS, but conflicted with our hypotheses of less RET and PT. Table one contains a summary of the results and highlights the findings associated with extrinsic mechanisms leading to SAIS.

During frontal plane elevation SAIS patients showed greater PT (z = -3.04, p = 0.002) and ER (z = -2.11, p = 0.035). During scapular plane elevation, SAIS showed less UR (z = 4.12, p<0.001) and ER (z = 2.68, p = 0.007) greater ELE (z = 2.65, p = 0.008) and RET (z = -3.08, p = 0.002) than controls. The same pattern was seen in the sagittal plane of greater ELE (z = 3.44, p<0.001) and RET (z = -1.96, p = 0.050). The largest effect was seen in the scapular plane of less scapular UR (ES = 0.47). Medium to small effects were seen in the scapular plane of less ER (ES = 0.39) and greater PT in the frontal plane (ES = -0.38), and a small effect of greater ER in the frontal plane (ES = -0.26) in subjects with SAIS.

Regarding arm elevation angle, there was a large effect of less UR (ES = 0.50, z = 3.36, p = 0.001) at arm angles below 90° of humeral elevation, in those with SAIS. The effects were small to moderate of greater ELE (ES = 0.46, z = 4.03, p< 0.001) and RET (ES = -0.30, z = -3.853, p<0.001) for kinematics collected at arm angles greater than 90° of humeral elevation.

In athletes with SAIS there was a large effect (ES = -0.66, z = -3.37, p = 0.001) of greater scapular PT, in overhead workers a large effect (ES = 0.83, z = 3.51, p< 0.001) of less PT was seen. These differences in scapular kinematics between athletes and overhead workers might be in part due to a diagnosis of internal impingement in the athletes. There was also a large effect of less scapular UR in athletes (ES = 0.70, z = 3.99, p<0.001) and in overhead workers (ES = 0.64, z = 3.36, p = 0.001). Moreover, there was a very large effect of less ER for overhead workers (ES = 1.05, z = 3.59, p<0.001). Effects were small to moderate for ELE (ES = 0.35, z = 3.83, p< 0.001) and RET (ES = -0.26, z = -4.06, p<0.001) in the general population for SAIS.

CONCLUSIONS

Overall, a pattern of decreased UR and ER, increased ELE and RET and no differences in PT was found in patients with SAIS. Analysis of the moderator variable arm elevation angle supports the need to focus on scapular control at low arm elevation angles. The plane of humeral elevation affects scapular kinematics, as deviations were inconsistent between planes of elevation with great differences being seen during scapular plane arm elevation. The differing pattern of scapular kinematics in athletes and overhead workers provides evidence for the further investigation of scapular motion differences in subgroups of individuals with shoulder pain. Some inconsistencies in scapular kinematics may be due to the activity of the individuals studied. Future investigation in this area should include exploration of the scapular kinematics in specific groups based on physical activities and injury diagnosis.

REFERENCES


Table 1: Meta-analysis results, summary of scapular and clavicular kinematic alterations in individuals with SAIS. Double arrows indicate alterations in shoulder motion that are consistent with the hypothesized extrinsic mechanism of SAIS by producing a reduction in subacromial space.

<table>
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<th>Shoulder Motion</th>
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SAIS, subacromial impingement;