Exercise Therapy Affects Glenohumeral Joint Stability In Patients With Isolated Supraspinatus Tears

Luke T. Mattar[1], Camille C. Johnson[2], Tom H. Gale[2], Adam J. Popchak[3], James J. Irrgang[3,2], William J. Anderst[2], Volker Musahl[2,1], Richard E. Debski[1,2]

[1] Departments of Bioengineering, [2] Department of Orthopaedic Surgery, & [3] Department of Physical Therapy
University of Pittsburgh

Introduction

Rotator cuff tears commonly occur in the supraspinatus tendon, an active compressor of the humeral head into the glenoid when performing external rotation in the abducted position [1]. Thus, it is important to understand the effect an isolated supraspinatus tear has on the efficacy of the internal and external rotators of the rotator cuff to stabilize the glenohumeral joint. Failure to improve joint stability following non-operative treatment may result in pain and the inability to perform activities of daily living.

Objective

Determine the effects of a 12-week exercise therapy program on rotator cuff muscle strength and glenohumeral kinematics during internal/external rotation at 90Á of humerothoracic abduction.

Methods

- Å 20 subjects (ages 45-70) recruited after providing IRB-approved written informed consent
  - Symptomatic degenerative rotator cuff tear isolated to supraspinatus

Exercise Therapy Protocol

- Å 12-week structured program
  - Focuses: Range of motion and strengthening of rotator cuff/scapular muscles
  - Subject progression based upon pain, range of motion, and strength

Dynamic Stereoradiography [2]

- Å Subjects performed internal/external rotation at 90Á of humerothoracic abduction

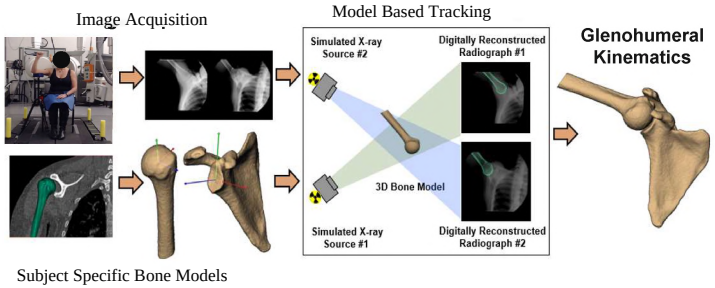

Figure 1: Overview of image acquisition and procedures for kinematic analysis

Pre- vs. Post-Exercise Therapy

- Å Comparisons made using largest shared internal/external range of motion between pre- and post-exercise therapy
- Å Outcome Parameters
  - Isometric internal/external rotation strength
  - Maximum glenohumeral external rotation
  - Contact path length (normalized to glenoid size)

Statistics

- Å Paired t-test or Wilcoxon Signed-Rank test to compare outcome parameters pre- vs. post-exercise therapy
  - $p < 0.05$

Results

Table 1: Pre- and Post-Exercise Therapy Kinematics and Isometric Muscle Strength

Outcome Measure	Maximum External Rotation (Å)		External Rotation Strength (N)		Internal Rotation Strength (N)		Contact Path Length (% Glenoid Size)	
Timepoint	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Mean ÑSD	93.6 Ñ12.3	97.8 Ñ13.4	66.2 Ñ31.6	89.7 Ñ40.5	103.3 Ñ42.8	120.1 Ñ48.7	31.3 Ñ20.0	23.1 Ñ10.2
p	0.038		0.001		0.003		0.037	

- Å All subjects successfully completed the exercise therapy program
  - 65% increase in maximum external rotation
  - 90% increase in external rotation strength
  - 90% increase in internal rotation strength
  - 60% decrease in contact path length

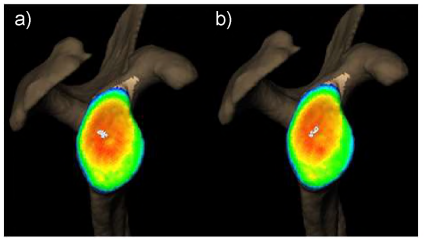

Figure 2: Representative contact path kinematics for a single subject during the internal and external rotation task. a) Pre-exercise therapy and b) post-exercise therapy. The contact path is represented by the white line.

Discussion

- Å Structured exercise therapy program focused on restoring range of motion and strength may improve joint stability
  - Improved strength of force couple created by subscapularis and infraspinatus → increased ability to pull humeral head into glenoid → decreased contact path length
- Å Previous study tested effects of exercise therapy on internal/external rotation with the arm by side → no effects on contact path length [3] → improvements may be task dependent

Future Directions

- Å Quantify effects of exercise therapy on glenohumeral kinematics longitudinally → determine if joint stability and motion are maintained
  - Determine factors that lead to success or failure of exercise therapy → improve current treatment methods

Significance

- Å A structured exercise therapy program improved glenohumeral joint stability during external rotation at 90Á of humerothoracic abduction
- Å Developing rotator cuff index may help assign non-operative or operative treatment to patients

Acknowledgements
Support from the National Institutes of Health grant 5R01AR069503 is gratefully acknowledged.

References
[1] Minagawa, H et al., J Orthop, 10:8-12, 2013.
[2] Bey, M et al., J Biomech Eng, 128:604-609, 2006.
[3] Ferrer, GA et al., KSSTA, 26:267-274, 2018.