# Predictors of Patient Reported Outcomes and Tear Propagation Immediately Following Exercise Therapy for Individuals with Rotator Cuff Tears

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**INTRODUCTION:** Non-operative treatment is generally prescribed for individuals with symptomatic rotator cuff tears and is successful for approximately 50-75% of individuals[1-4]. Non-operative treatment has been shown to have beneficial effects on range of motion, muscle strength, and patient reported outcomes[4-6]. However, difficulties remain regarding the ability to determine which individuals will be successfully treated with exercise therapy alone or eventually require surgical intervention. Determining factors that predict outcomes such as patient reported outcome scores and tear propagation will allow clinicians to make informed decisions on treatment plans on an individual basis. Thus, the objective of the study was to prospectively identify factors that predict patient reported outcomes and tear size propagation immediately following exercise therapy. Predictors included glenohumeral contact path lengths during scapular plane abduction, initial tear size, passive range of motion and isometric muscle strength.

**METHODS:** 109 individuals (age 60.9±9.9 years; 56 males, 53 females; BMI 28.7±5.0 kg/m$^2$) with a symptomatic rotator cuff tear isolated to the supraspinatus tendon provided IRB-approved written informed consent prior to participation in this study. Each individual participated in a 12-week personalized exercise therapy program where specific exercises utilized were based on the impairments identified during the initial examination, and a set of pre-defined clinical decision-making criteria were utilized to address each impairment. Supraspinatus tear size before and after 12 weeks of exercise was assessed using ultrasonography (US) and in-vivo glenohumeral kinematics during scapular plane abduction were collected using bi-plane radiography and a previously validated model-based tracking technique (accuracy of ±0.4mm and ±0.5°)[8]. Tear size was quantified as the anterior-posterior (AP) distance of the tear measured perpendicular to a line tangent to the posterior edge of the long head of the biceps tendon on a short axis image. Propagation was defined as changes in tear size ≥4.6mm based on our internal calculation of the minimal detectable change. Contact path lengths were quantified using the biplane radiography system, which estimates the amount of displacement of the humeral head on the glenoid surface (determined using bone-to-bone distances, normalized to glenoid size)[9,10]. Passive glenohumeral abduction (involved side) and isometric strength (external and internal rotation at 0° abduction and "full can" abduction at 90° abduction in the scapular plane) were assessed by a physical therapist using a goniometer and handheld dynamometer, respectively. Isometric strength was normalized to the noninvolved side. Individuals also completed the Western Ontario Rotator Cuff index (WORC, 0-100, higher scores indicate less pain and better function)[11] before and after exercise therapy. Univariable and multivariable regression analyses and logistic regression were utilized to determine if patient reported outcome scores (WORC) and tear propagation at 3-months, respectively, were predicted by glenohumeral kinematics, tear size, passive range of motion and isometric strength collected prior to exercise therapy. Significance was set at $p < 0.1$ given the exploratory nature of the analyses.

**RESULTS:** WORC scores following exercise therapy were 82.2 ± 19.6 and improved by 21.7 ± 19.2 compared to pre-exercise therapy. The regression results indicated that WORC scores at 3-months were independently predicted by isometric internal and external rotation measured with the shoulder in neutral rotation with the arm at 0° of abduction (Table 1). Eight (7.3%) participants experienced tear propagation (change in tear size ≥4.6mm) at 3-month follow-up. Tear propagation at 3-months was predicted by baseline tear size (Odds Ratio = 0.70, p=0.01) indicating that a 30% decrease existed in the odds for tear propagation for each one-millimeter increase in initial rotator cuff tear size.

**DISCUSSION:** The implications of the current findings are that changes in patient reported outcomes immediately after exercise therapy can be predicted by the strength of the rotator cuff before exercise therapy. From the clinical perspective, strength is modifiable with exercise therapy. To further improve and maintain strength after supervised physical therapy, individuals with a rotator cuff tear should continue with home exercises using elastic bands or light weights that may aid in maintaining improvements in patient reported outcomes long-term. Additionally, individuals with a larger tear isolated to the supraspinatus tendon at baseline had a decreased risk of tear propagation immediately following exercise therapy, necessitating additional investigations to better elucidate the implications of this result. These investigations should consider the relationship between initial tear size; longitudinal changes in tear size; quality of tissue; and strength. Future work will aim to identify factors capable of predicting patient reported outcomes and tear propagation at 2- and 5-years following exercise therapy.

**SIGNIFICANCE/CLINICAL RELEVANCE:** The current study provides information to clinicians to inform decisions regarding who may respond to an individualized exercise therapy program. Continual strengthening may improve and maintain patient reported outcomes following exercise therapy.

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**ACKNOWLEDGEMENTS:** Support from the National Institutes of Health grant 5R01AR069503 is gratefully acknowledged.

**Table 1:** Variables measured before exercise therapy that predict WORC scores immediately following a 12-week personalized exercise therapy program.

| Variable | Parameter Estimate | Standard Error | t Value | Pr > \|t\| | 95% Confidence Limits | |
|---|---|---|---|---|---|---|
| **Intercept** | 59.64 | 7.40 | 8.10 | <.0001 | 45.0 | 74.2 |
| **External Rotation 0° Strength** | 0.09 | 0.05 | 1.81 | 0.0731 | 0.0 | 0.2 |
| **Internal Rotation 0° Strength** | 0.18 | 0.09 | 2.04 | 0.0439 | 0.0 | 0.4 |