**INTRODUCTION**

Subacromial outlet impingement is the most common cause of shoulder pain. Rotator cuff (RTC) dysfunction has been postulated to contribute to shoulder impingement syndrome (SIS). Fatigue of the muscles of the RTC may result in increased superior glenohumeral migration, decreasing the subacromial space (Chen et al. 1998 & Deutsch et al. 1996). Gaining a better understanding of the effects of RTC fatigue on glenohumeral kinematics during dynamic motion, both in normal subjects and patients diagnosed with SIS, may provide improved insight into the etiology of SIS, more accurate and timely diagnostic techniques, and more focused treatments for patients suffering from shoulder pathologies such as SIS. The purposes of this study were to: 1) describe superior-inferior glenohumeral migration during arm elevation in individuals with SIS, 2) analyze the effect of RTC fatigue on glenohumeral migration and 3) determine interrater reliability for analyzing dynamic glenohumeral migration using digital fluoroscopic videos (DFV).

**METHODS**

Prior to subject recruitment, interrater reliability was established using DFV from 10 subjects in the lab database. An ICC (2,3) was utilized to determine reliability between raters.

Twenty male volunteers (27.70 ± 7.25 years) with right SIS completed this study. Three DFV of arm elevation in the plane of the scapula were collected for each subject at 30 Hz using a Dynamic Motion X-Ray (DMX-Works Inc., Palm Harbor, FL). DFV were obtained both pre- and post-fatigue of the RTC.

Fatigue of the RTC was achieved utilizing a protocol adapted from Chen et al. (1998). Fatigue was confirmed by at least a 40% strength decrement as measured by a hand held dynamometer. The DFV were analyzed according to the methods described by Chen et al. (1998) from 0-135°. The pre- and post-fatigue DFV were compared to assess the difference in humeral head migration due to RTC fatigue.

This study utilized a 2×4 repeated measures ANOVA in order to contrast humeral head migration at 0, 45, 90, and 135° pre- and post-fatigue (α = .05). Post hoc analysis utilized paired t-tests with a Bonferroni correction.

**RESULTS AND DISCUSSION**

The ICC (2,3) values ranged from 0.70-0.92 with a SEM ranging from 0.534 to 0.644 mm (approximately 1.6 pixels). The repeated measures ANOVA revealed a main effect for fatigue state (p = 0.025) and arm angle (p = 0.017). Post hoc paired t-tests, with a Bonferroni Correction, revealed
significant superior migration between 45° and 135° prior to fatigue of the RTC (p = 0.040). Post-fatigue, the position of the humeral head was more superior at the arm at side position (p = 0.035). There was no interaction effect between angle and fatigue state (p = 0.093) (Figure 1).

![Glenohumeral Migration Graph](image-url)

**Figure 1:** Glenohumeral migration during arm elevation, pre- and post- RTC fatigue.

The amount of superior migration during arm elevation pre-fatigue is consistent with prior reports (Deutsch et al. 1996 & Ludewig & Cook 2002) when analyzing subjects with SIS, and normal subjects during dynamic motion of the arm (Ludewig & Cook 2002 & Miller et al. 2003). However, the position of the humeral head in SIS subjects was more superior on the glenoid fossa when compared to normal subjects studied by Miller et al. (2003). Our results differ from previous studies (Chen et al. 1998 & Deutsch et al. 1996), which found no significant glenohumeral migration prior to RTC fatigue in non-pathologic shoulders. These differences may be attributable to the type of contraction utilized in the studies (dynamic versus isometric), or due to the subject’s condition (non-pathologic versus SIS).

Following the RTC fatigue protocol, the humerus was positioned more superiorly on the glenoid fossa at the arm at side position, when compared to the pre-fatigue state. No significant differences were found at higher angles of elevation. Prior studies (Chen et al. 1998 & Miller et al. 2003) of normal subjects have found significant differences in humeral head position between fatigue states at higher angles of elevation. A possible explanation for these differences could be that the humeral head began more superiorly on the glenoid fossa following fatigue in our SIS subjects. This could potentially narrow the subacromial space and create a “ceiling effect” thereby limiting additional superior glenohumeral migration.

**SUMMARY**

DFV analysis is a reliable tool for studying glenohumeral kinematics during arm elevation. Prior to fatigue of the rotator cuff, superior migration of the humeral head was consistent with previous studies analyzing both normal and pathological shoulders. The more superior position of the humeral head following RTC fatigue may indicate the importance of the dynamic stabilizers of the shoulder at angles below 45° of arm elevation.

**REFERENCES**


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