INTRODUCTION

Superior migration of the humeral head with respect to the glenoid has been found to occur during humeral elevation with shoulder impingement syndrome, with rotator cuff (RTC) tears (Deutsch et al, 1996), and with fatigue (Chen & Chen, 1998). However, only minimal humeral head migration was found to occur in those without shoulder pathology (Chen & Chen, 1998, Poppen & Walker, 1976). These analyses of the arthrokinematics utilized repetitive static standard radiographs to quantify the glenohumeral positions under isometric conditions. Dynamic analysis of frontal plane arthrokinematics during elevation has not been reported. The purposes of this study were to analyze humeral head migration during humeral elevation (0-135°) in those without shoulder pathology 1) to assess the test-retest reliability, 2) to describe normal humeral head migration patterns, and 3) to investigate the effect of RTC fatigue on superior humeral head migration.

METHODS

A convenience sample of 20 males without shoulder pathology, 18-35 years of age (27.95 ± 3.69 years), completed this study.

Three cineradiographic images (Dynamic Motion X-Ray, DMX-Works Inc., Palm Harbor, FL) of humeral elevation in the plane of the scapula were collected at 30 Hz for each subject. Two pre-fatigue humeral elevation trials were used to assess test-retest reliability at 0, 45, 90, and 135° of humeral elevation.

Subjects then performed a RTC fatigue protocol adapted from Chen & Chen (1998) and Blackburn & Wofford (1990). Fatigue was estimated when the subject could not continue to lift the arm past 45° on three consecutive trials and was confirmed by a least a 40% strength decrement as measured by a hand held dynamometer with humeral elevation. After fatigue was established, a final set of images was obtained.

The digital images were analyzed according to the methods described by Chen & Chen (1998) from 0-135°. An ICC (3, 1) was used to establish test-retest reliability at the pre-selected angles. The first pre-fatigue and the post-fatigue trials were compared to assess the difference in humeral head migration due to RTC fatigue. This study utilized a 2x4 (fatigue by position) repeated measures ANOVA in order to contrast humeral head migration at 0, 45, 90, and 135° with and without fatigue (α = .05).

RESULTS AND DISCUSSION:

The test-retest reliability among this sample ranged from good to excellent (.77 to .92) with a SEM ranging from .54 to .657 mm (approximately 1.6 pixels).
Repeated measures ANOVA revealed a main effect for angle ($p<.001$). Pair-wise t-test with a Bonferroni Correction revealed that superior migration at $0^\circ$ was significantly different ($p<.001$) from superior migration at $45, 90,$ and $135^\circ$ (Figure 1). Of the 40 pre- and post-fatigue trials analyzed, 33 demonstrated this trend. However, 7 demonstrated either inferior or relatively no migration.

![Graph showing shoulder angle vs. humeral migration](image)

**Figure 1:** Mean superior migration of the humeral head with elevation during both pre- and post-fatigue for all subjects.

There was no significant effect for pre-to post-fatigue ($p=.224$) and no interaction between angle and fatigue state ($p=.956$). These results indicate that the humeral head migration was associated with humeral head position and not the state of fatigue. Pre-fatigue and post-fatigue maximal elevation occurred at $90^\circ$ with $2.14 \pm 1.49$ mm and $2.26 \pm 1.24$ mm superior migration, respectively.

The combined findings of superior migration of the humeral head in those without shoulder pathology and the finding of no significant difference between due to RTC fatigue are in contrast to prior reports (Chen & Chen, 1998). In our study, it does not appear that the amount of fatigue could be an explanation for this contradiction. The fatigue strength of the subjects was $53\% \pm 8.6\%$ of the original strength. Chen & Chen (1998) defined fatigue as a 40% reduction in strength. Further, there was no correlation ($r = .152, p=.592$) between the percent fatigue and the amount of migration change post-fatigue. Additionally, the time from the end of the fatigue protocol to the post-fatigue assessment was also controlled ($16.64 \pm 1.96$ s). It is hypothesized that a measurement difference between the static radiographs versus cineradiographic imaging techniques, or the difference between RTC activation during isometric and concentric conditions, may explain this discrepancy. Further study is needed to address these questions.

**SUMMARY:**

Cineradiographic assessment of shoulder kinematics provides a reliable tool for studying the underlying arthrokinematics during humeral elevation. Further, during humeral elevation there is superior migration of the humeral head that does not increase with RTC fatigue in subjects without shoulder pathology. The effect of RTC fatigue on those with shoulder pathology is unknown and currently under investigation in our laboratory.

**REFERENCES:**


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