Effects of Hand-held Weights on in-vivo Scapular Tilting during Arm Elevation

1Matsuhisa T; 2Tsutsui H; 2Mihara K; 3Suzuki K; 4Nishinaka N; 5Uehara T; 5Nishinaka N; 1Uehara T; 4Teikyo University Chiba Medical Center, Ichihara, Chiba, Japan; 5University of Florida, Gainesville, FL, USA
Senior author tsutsui@yk.rim.or.jp

INTRODUCTION
Arm elevation consists of both glenohumeral (GH) and scapulothoracic (ST) motion. It is reported that upward rotation, adduction and posterior tilting provide stability of the glenohumeral joint allowing efficient rotator cuff and deltoid muscle function in shoulder motion [1]. A variety of methods have been used in previous studies to describe upward rotation (scapulohumeral rhythm). Some authors reported that a large resistance caused an increase in scapulohumeral rhythm during elevation of the arm in the scapular plane [2][3]. However dynamic posterior tilting of the scapula has yet to be fully elucidated.

The purpose of this study was to determine in vivo the influence of lifting 3kg hand-held weights on scapular tilting during abduction in the scapular plane. We hypothesized that the scapula would tilt posteriorly during abduction in asymptomatic subjects. We also hypothesized that tilting angles would not be different during the loaded and unloaded trials.

METHODS
Five dominant-side shoulders in five subjects (2 males, 3 females; average 29.4 years, 27 to 34 years) were studied. All shoulders were asymptomatic, had no history of injury, and lacked any clinical or radiographic signs of pathology. All subjects provided informed consent to participate in this IRB approved study. CT scans of each shoulder were acquired at 0.5 mm intervals and 3D models of the scapula and humerus were created. The subjects were positioned in front of a fluoroscope and motions were recorded during active abduction from 0°-120° in the plane of the scapula. The subjects performed two trials: one trial holding a 3kg weight (loaded) and one trial without the weight (unloaded). 3D motions of the scapula and humerus were determined using model-based 3D-to-2D registration (Fig. 1). The measured 3D kinematics of the humerus and scapula were analyzed to determine scapular tilting and arm abduction. Repeated-measure analysis of variance (ANOVA) and post-hoc pairwise comparisons (Tukey) were used for the analysis of the tilting changes within the subjects.

RESULTS
During arm abduction, the scapula was tilted posteriorly 19.0 ± 7.7° and 20.5 ± 2.7° in the loaded and unloaded trials, respectively. There were no statistically significant differences in scapular tilting between the loaded and unloaded trials (Fig 2).

DISCUSSION
There have been few articles that address the tilting angle of the scapula [4][5]. Ludewig, using an electromagnetic tracking device, reported that the scapula tilted posteriorly approximately 19° during elevation activity, which is similar to our result. Previous studies using 3D-to-2D model registration techniques showed that scapular upward rotation decreased over the range of glenohumeral abduction angles while holding a weight. In contrast, there have been very few reports to measure tilting angle of the scapula with weighted condition. This study showed that there were no significant differences in scapular tilting between the loaded and unloaded trials of arm abduction, suggesting that scapular tilting, unlike scapular upward rotation, is not affected by resistance. It appears the muscles around the scapula, such as the trapezius and serratus anterior, work in concert to control scapular tilting motion within an invariable range not dependant on loaded or unloaded conditions.

REFERENCES