INTRODUCTION: Overhead athletes develop a shift toward greater external rotation to accommodate their throwing arc and commonly a posterior inferior contracture which causes a lack of internal rotation. The anterior laxity and posterior tightness leads to pathological changes within the glenohumeral joint such as labral and rotator cuff dysfunction. Both internal impingement (1) and the peel-back mechanism (2) have emerged to explain the capsular effect and its associated pathology. This study seeks to recreate the capsular pathology in a cadaver model in order to reveal the precise biomechanical effect on glenohumeral motion. The precise goals are three-fold. First, to create a cadaveric model of the overhead athlete shoulder by creating anterior laxity and simulating a posterior capsular contracture. Therefore, the result should increase external rotation and decrease internal rotation, respectively. The second goal is to record the humeral head shift in relation to the glenoid during the late cocking phase of throwing. Lastly, the translational effects of these capsular changes will be examined. A cadaver model cannot reproduce clinical instability. However, the model can develop laxity, which was defined as a significant increase in translation.

MATERIALS AND METHODS: Ten fresh frozen cadaveric shoulders were used in the study. The shoulder testing system was created to measure glenohumeral rotation, position of the humerus with respect to the glenoid, and glenohumeral translation (Figure 1). The testing apparatus allowed six degree-of-freedom for glenohumeral positioning. A Microscribe 3DLX (Immersion Corp, San Jose, CA) was used to measure glenohumeral translations. Three sets of specific measurements were obtained for each of the following specimen conditions: intact, after anterior capsular stretching, and simulated posterior contracture. The three measurements included rotation, humeral shift, and translation. The total range of motion, external rotation, and internal rotation was recorded with a 360 degree goniometer. Humeral shift was calculated by measuring and comparing humeral head position with respect to the glenoid at neutral humeral rotation, 90 degrees external rotation, and maximum external rotation. Glenohumeral translations were measured with a compressive load of 22 N and translational loads of 15 and 20N applied to the shoulder in the anterior, posterior, superior, and inferior directions. Stretching of the anterior capsule in external rotation created anterior laxity. A 30 percent increase of maximum external rotation was achieved with a gradual increase in torque applied to the shoulder. Rotation, glenoid shift, and translation measurements were repeated as previously described. A glenoid based posterior capsular shift was performed to simulate a posterior contracture. Care was taken to leave the superior leaflet in its anatomic position. The inferior leaflet was shifted 10mm superiorly. The repair was achieved with No. One Ethibond suture. Rotation, glenoid shift, and translation measurements were repeated as previously described for a third and final trial. A two tailed, paired t-test was used to analyze the data for each set of measurements performed within the experiment.

RESULTS: After stretching there was a significant increase in external rotation (18.2°, p<0.001) followed by a decrease in internal rotation with the simulated posterior contracture (8.8°, p=0.005) (Figure 2). Rotation of the humerus from neutral to maximum external rotation caused a posterior-inferior shift of the humeral head. Following simulated posterior capsular contracture there was a significant superior shift of the humeral head when compared to the stretched condition (1.95mm, p=0.013) (Figure 3). Results of translation testing showed a consistent increase in all primary directions from intact to the anterior laxity phase. Significance was achieved solely in the primary anterior direction with 15N (2.54±1.04mm, p=0.038) and 20N (1.72±0.27mm, p<0.001). A simulated posterior contracture significantly decreased anterior translation with the 15N load when compared to the stretched condition but did not affect translation within the 20N load was applied.

DISCUSSION: The cadaver model developed successfully recreated the overhead athlete. A significant increase in external rotation was achieved through creation of significant anterior laxity. A simulated posterior contracture significantly decreased internal rotation. With regard to humeral shift, the posterior capsular contracture does not allow the humerus to externally rotate into its normal posterior-inferior position. Instead, the humeral head is forced posterior-superior which may explain the etiology of SLAP lesions and rotator cuff tears in overhead athletes.