INTRODUCTION

The shoulder is the most commonly dislocated joint in the body. Unidirectional anterior glenohumeral dislocation, which accounts for 80 percent, occurs in the shoulder position of abduction, external rotation and horizontal abduction. Diagnosis of instability is confirmed when simulation of this position yields apprehension that the joint will dislocate, hence the term "apprehension position." Initial treatment includes an aggressive rehabilitation program and avoidance of the apprehension position. Unfortunately, recurrent instability remains a meaningful problem, especially in young individuals who are frequently asymptomatic except when the shoulder is placed in the apprehension position. The reason that this position results in instability remains unknown. The purpose of this study was to quantify the translation and force of the joint at two positions: 1) abducted 90 degrees in the plane of the scapula and, 2) the apprehension position.

METHODS

Five cadaveric, whole upper extremities with a mean age of 77.5± 6.4 years were used. The glenohumeral joints were then dissected to leave the tendons of the rotator cuff, anterior and posterior deltoid and the joint capsule. The coracohumeral, coracoclavicular, and acromioclavicular ligaments, and anterior portions of the deltoïd, long head of the biceps and triceps were left intact. All joints distal to the glenohumeral joint were rigidly fixed with the elbow flexed 90 degrees and the wrist and fingers in extension. The scapula was fixed in a custom positioning/fixedation box. The scapula box was then mounted onto a custom joint loading frame which enabled individual control of simulated muscles as well as the measurement of joint translation and force (resolved into 3 forces along the 3 orthogonal axes with the center of the glenoid as the origin) (FIGURE 1). This custom joint loading frame permitted simultaneous control of five muscle groups (1). A backplate with multiple cable housings and a pulley permitted the control of each muscle force direction and the load. The neutral position for each individual intact specimen under static conditions was determined and used as a reference position. The rotator cuff muscle force vectors were defined as the lines of action from the tendon insertions through the centroids of the muscles. The anterior and middle deltoid vectors were defined by the muscle origins and insertions. The subscapularis and infraspinatus were included for joint stability and to balance the anterior-posterior force couple. The joint force insertion points for the rotator cuff, anterior and posterior deltoid and the joint capsule. The subscapularis and infraspinatus were included for joint stability and to balance the anterior-posterior force couple. The joint force vector was measured using a 6 degree of freedom load cell (Assurance Technologies Inc., Garner, NC) and joint translation was measured with an electromagnetic sensor (The Bird, Ascension Technology, Colchester, VT). For the simulated muscle loading the scapula was abducted 30 degrees and sufficient load was then applied to the tendons of the rotator cuff and the deltoid (anterior and posterior portions) to achieve 60 degrees of glenohumeral abduction in the plane of the scapula. This simulated a total of 90 degrees of shoulder abduction, where instability is common, and then the joint was placed in full external rotation and horizontal abduction. Joint translation and force were recorded. The joint was then additionally placed in full horizontal abduction and the joint translation and force recordings were repeated. A paired t-test was used to compare the translations and forces (of the 3 orthogonal axes) before and after simulation of the apprehension position. A p-value of 0.05 was used as the level of significance.

RESULTS

The glenohumeral joint force was resolved into three orthogonal components. The three resolved force components are: 1. force perpendicular to the glenoid (joint compression force); 2. force directed anterior to the glenoid (anterior shear force); 3. the force directed inferior to the glenoid (inferior shear force). With the humerus in the plane of the scapula the magnitude of the force directed perpendicular to the glenoid was large (152± 13N) and remained approximately the same (151±13N) when the humerus was placed in the apprehension position. The magnitude of the force directed anterior to the glenoid was 1±4N and increased significantly to 28±12N when the humerus was placed in the apprehension position. The magnitude of the force directed inferior to the glenoid decreased from 33±5N to 25±5N when the humerus was moved from the scapular plane to the apprehension position. There was also no translation of the humeral head on the glenoid (p=0.05) in comparison of the two positions.

DISCUSSION

Joint position had a significant effect on the magnitude of the joint force about the orthogonal axis directed anterior to the glenoid. This likely resulted from the force changing to a more anterior direction when the shoulder was placed in the apprehension position. The joint force is a primary active stabilizer of the shoulder as long as it is directed into the glenoid. Although the glenohumeral joint translation was not affected by the joint position, the results from this study suggest that the alteration of the joint force with the shoulder in the apprehension position predisposes to anterior shoulder instability.

Force Vectors of the Glenohumeral Joint

![Force Vectors of the Glenohumeral Joint](image)

FIGURE 1. A schematic drawing showing the skeletal view of the setup that was used to measure glenohumeral joint kinematics with Simulated Muscle Forces. Also note the six degree-of-freedom load cell used to measure the magnitude and direction of the glenohumeral joint compression force. The muscle forces are not shown.

![Glenohumeral Joint Force](image)

FIGURE 2. Histograms showing three resolved glenohumeral joint forces for scapular plane abduction and in the position apprehension.

REFERENCES


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