SCAPULAR JOINT POSITION SENSE AT DIFFERENT ARM ELEVATION ANGLES

Yin-Liang Lin and Andrew Karduna
Department of Human Physiology, University of Oregon, Eugene, OR USA
email: yinliang@uoregon.edu, web: http://physiology.uoregon.edu/

INTRODUCTION
The human shoulder complex sacrifices stability in exchange for the large range of motion necessary for hand manipulation. The central nervous system uses proprioception to help coordinate muscle activity around the shoulder to provide dynamic stability during movement. Proprioception information is provided by afferent signals from musculotendinous, cutaneous, and capsuloligamentous mechanoreceptors [1]. Impaired proprioception has been found to be associated with shoulder injuries [2].

The shoulder complex consists of the glenohumeral, acromioclavicular, scapulothoracic, and sternoclavicular articulations. The coordination between the scapula and humerus during arm movement has been well investigated. Patients with shoulder impingement and instability demonstrate impaired scapular kinematics [3]. However, when shoulder proprioception was tested, previous studies have only focused on overall shoulder movement [2].

In healthy subjects, it has been shown that overall shoulder proprioception improves with elevation angles [4]. However, it is still unknown how the scapula contributes to overall errors of shoulder complex. The purpose of this study is to investigate joint position sense (JPS) of the shoulder joint, including glenohumeral and scapulothoracic joints, at different elevation angles in the scapular plane.

METHODS
Four healthy subjects (1 male and 3 females, 24-43 years old) were tested. JPS was tested with an active position reproduction test. A magnetic tracking device (Polhemus Liberty, Colchester, VT) was used to measure scapular, humeral and thoracic kinematics. Subjects wore a head mounted display, which provided visual cues for the target position and blocked the visual feedback on the arm position. A custom written LabVIEW program (National Instruments, Austin, TX) guided subjects to move their arm to a specific target elevation of the humerus with respect to the thorax in scapular plane, 30° anterior to the frontal plane.

After the subject had maintained the arm in the target position for one second, the display turned completely black to remove all visual feedback. Subjects held their arms and memorized the target position. Then subjects were instructed to return to the rest position. After three seconds with arm at rest position, subjects were prompted with another verbal cue to return to the target position. The subjects indicated when they believed they had reached the target by pushing a button on a wireless presenter remote with their contralateral hand [5].

Three target positions were presented: humerothoracic elevation angles of 50°, 70°, and 90° in the scapular plane. Root mean square (rms) errors were calculated to represent the accuracy of the reposition. This present study only focused on the elevation angles of humerothoracic and glenohumeral joint and upward rotation of the scapula.

RESULTS AND DISCUSSION
Figure 1 shows the average of rms errors for humerothoracic elevation, glenohumeral elevation, and scapular upward rotation at 50°, 70°, and 90° of humerothoracic elevation in scapular plane. The errors of glenohumeral elevation and scapular upward rotation demonstrated the same patterns as the humerothoracic elevation: the errors decreased with the increase of elevation angle and the errors were higher at 50° compared to those at 90°.

Strong correlation was also found between the errors of humerothoracic elevation and glenohumeral elevation ($r = 0.79$), and between humerothoracic elevation and scapular upward rotation ($r = 0.69$). Therefore, during arm elevation, the scapula also contributes the errors of the overall shoulder movement.

CONCLUSIONS
When shoulder proprioception is investigated, it may be helpful to examine the proprioception of individual joints, including glenohumeral and scapulothoracic joints. Both glenohumeral and scapulothoracic joints contribute the overall errors of humerothoracic joint.

REFERENCES
1. Sherrington CS. Brain 29, 467-482, 1906