SCAPULOTHORACIC JOINT KINEMATICS DURING CONSTRAINED AND UNCONSTRAINED MOVEMENTS

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INTRODUCTION

Scapular kinematics is a very important component of shoulder motion. Researchers trying to measure scapulohumeral kinematics typically use constrained protocols. These protocols include constraining the humeral movement to specific planes such as the scapular, frontal and sagittal planes and restricting motion of the wrist, elbow and thorax (Ludewig et al. 1996; McClure et al. 2001). In contrast, there are studies measuring scapular kinematics in unconstrained scenarios such as wheelchair propulsion (Nawoczenski et al. 2003).

To the best of our knowledge there have been no published studies comparing scapular kinematics between constrained and unconstrained humeral movements. Therefore, the purpose of this study was to test the influence of constrained and unconstrained humeral movements on scapular kinematics.

METHODS

Five healthy subjects (3 males, 2 females) participated in this study (mean age, 30.8 years). Kinematic data were collected via the Polhemus Liberty magnetic tracking system with three receivers: thorax, scapula and humerus. The thoracic receiver was attached using double side adhesive tape to the manubrium below the jugular notch. The scapular receiver was attached using a scapula tracker jig and Velcro strips on the scapular spine and acromion process (Karduna et al. 2001). The humeral receiver was placed over the deltoid tuberosity using a molded cuff. For all trials, data were collected at a rate of 120 Hz (Figure 1).

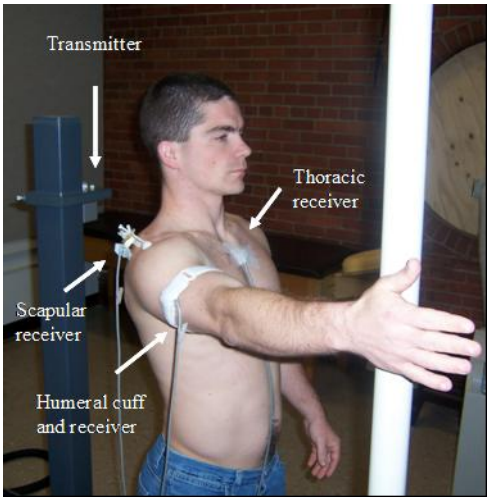

Figure 1. Experimental setup

During calibration and data collection trials subjects were in a standing position. Global and anatomical coordinate systems were based on the ISB recommendation for the upper extremity (Wu et al. 2005). Each subject performed one unconstrained movement which was reaching to a car seatbelt; we chose this natural movement because it crosses many humeral planes of elevation. After data collection for the unconstrained movement, the subject performed constrained movements consisting of arm elevation in different planes, starting with the frontal plane (0^o) and ending with their maximal plane of elevation. The plane changed in increments of approximately 10^o and a plastic pole was

used to indicate a specific plane. In the constrained trials the subjects were instructed to keep their elbow extended and thumb pointing to the ceiling.

Using the constrained data for each subject, we plotted the humeral plane of elevation and elevation. We then superimposed the unconstrained collected data of humeral plane of elevation and elevation on the constrained graph (Figure 2). Using this graph we identified crossing points of the constrained and unconstrained motions. Each one of these points was associated with three scapular angles (protraction, lateral rotation and posterior tilt). For each of these intersected points the scapular angles were compared between the constrained and unconstrained humeral movements.

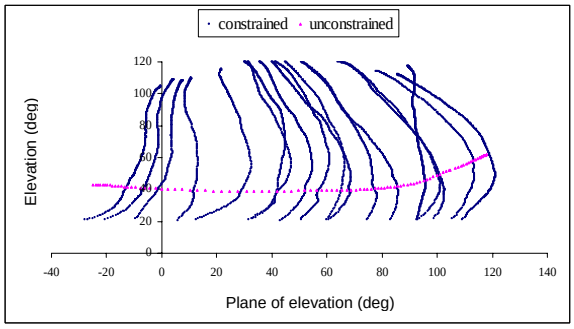

Figure 2. Representative trial of constrained and unconstrained humeral movement

RESULTS AND DISCUSSION

The mean residuals (unconstrained minus constrained scapular angles) were $0.2^o \pm 2.3^o$ for retraction/protraction, $4.7^o \pm 4.5^o$ for lateral/medial rotation and $-1.3^o \pm 1.6^o$ for anterior/posterior tilt. The residuals occurring at the measured humeral plane of elevation (Figure 3) and humeral elevation were found to be distributed over the whole measured range of motion.

Furthermore, scapular lateral rotation angles were higher in the constrained movement, in some cases by more than 15^o. Alternatively scapular posterior tilt angles were as much as 5^o lower in the constrained movement. However, for scapular protraction angles there were no obvious trend to the residuals between the constrained and unconstrained movement.

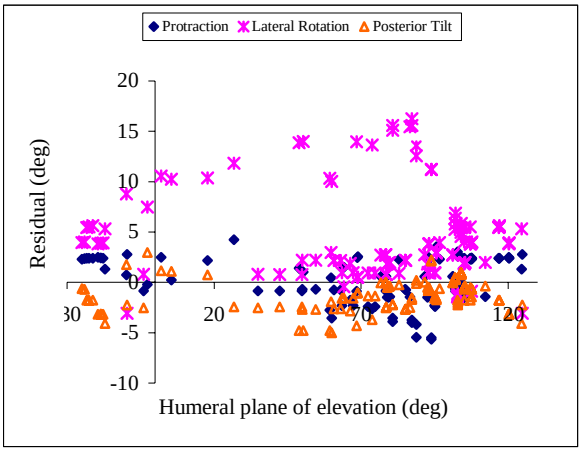

Figure 3. Effect of humeral plane of elevation on scapular residual angles

SUMMARY/CONCLUSIONS

The results from this preliminary study demonstrate that there are differences in scapular orientations between constrained and unconstrained humeral movements. This may indicate that the use of constrained movement to represent scapular orientation in unconstrained movement may not be appropriate. Further study in this area is needed.

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