Measuring In-vivo Humeral Head Translation using Fluoroscopy: A Comparison of Static and Dynamic Positioning

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INTRODUCTION

Subacromial impingement syndrome (SAIS) of the shoulder is the most common disorder of the shoulder, accounting for 44 – 65% of all complaints of shoulder pain during a physician office visit (Michener et al., 2003). Abnormal superior translation of the humeral head is believed to be one of the major causes of this pathology (Deutsch et al., 1996). There are numerous techniques used to assess humeral head translation. The most common techniques utilize include roentgenogram (X-ray), fluoroscopy, and magnetic resonance imaging (MRI). During data collection, images of the shoulder complex are either taken statically or dynamically. Numerous authors have argued that dynamic shoulder motion occurs frequently in everyday living, although, to our knowledge, there have been no studies comparing humeral head motion between static and dynamic motions. Therefore, the purpose of this study is to compare humeral head translations between static and dynamic trials in healthy individuals.

METHODS AND PROCEDURES

Three healthy subjects (age 22 ± 2.2, weight 68.9 ± 5.4 kg, height 166.8 ± 10.4 cm) participated in the study. Subjects were asked to perform two different conditions of shoulder elevation. The first condition involved dynamic shoulder elevation and the second condition involved holding the arm statically at different angles of shoulder elevation (i.e. 30°, 60°, 90°, and 120°). Each condition consisted of one trial. There was a 5 minute rest interval between conditions. Subjects started with their arm at the side.

During condition 1 (dynamic), the subject elevated their dominant arm in the scapular plane up to 120° of shoulder elevation for three repetitions. They were instructed to elevate their arm within 4 seconds and lower their arm also in 4 seconds. For the second condition (static), the subject was passively positioned by the investigator in five different elevation angles (0°, 30°, 60°, 90°, and 120°) in the scapular plane and was directed to hold their arm actively in the set position. In each of the trials, fluoroscopic images were taken.

During practice trials, the investigator positioned the subject so that the anterior side of the scapula was perpendicular to the field of view of the fluoroscope (Figure 1). By doing this, projection errors were minimized. During the dynamic trials, continuous imaging was utilized to capture shoulder elevation (8 pps).

Kinematic data were collected using a GE (OEC) 9800 Fluoroscopy unit. In addition, points were digitized on the glenoid face, the humeral head and the humeral shaft using Space (University of Oregon), which is an edge detection software. Humeral head translation was measured using a 2-D registration technique developed by Crisco et al (1995). In order to compare the static and dynamic trials, humeral elevation angles for both conditions were matched by calculating the humeral angle of each static position with respect to gravity. The measured superior humeral head translation was calculated in

each humeral elevation angle with respect to the resting position, which is defined as the 0° position during the static trial. This method of measuring humeral head translation was previously validated by the investigator with a measured error of less than 0.5 mm.

Fig. 1. Subject set-up during testing protocol.

RESULTS

During the static trials, the greatest measured superior humeral head translation occurred when the humerus was at 60° of elevation (4.4 ± 1.7). During the dynamic trials, both the 60° (4.2 ± 1.5) and 120° (4.2 ± 0.9) of humeral elevation angle showed the largest measured superior translation. There was a large difference in measured superior humeral head translation when the humerus was at a 120° of elevation (3.0 ± 1.1).

DISCUSSION

Dynamic motions performed during shoulder experiments better represent the actions Performed in activities of daily living. This study has shown that there is a difference in the measurement of humeral head translation between static and dynamic trials. The greatest difference occurred at 120° with a measured difference of 3.0 ± 1.1 mm. In this study, the dynamic trial had a greater amount of measured humeral head translation (1.4mm) above 90°. This result is important because studies have shown that overhead activities occur above 90° of humeral elevation, and repetitive overhead activities could lead to SAIS. However, care should be taken when interpreting the results of this study due to the limited number of subjects. This is an ongoing research study and the investigators are planning on testing more subjects.

SUMMARY

The dynamic motion of the shoulder should be taken into consideration during experimental protocol design especially when measuring glenohumeral kinematics. Static trials might elicit different muscle activation patterns to stabilize the humeral head compared to dynamic motions during shoulder elevation.

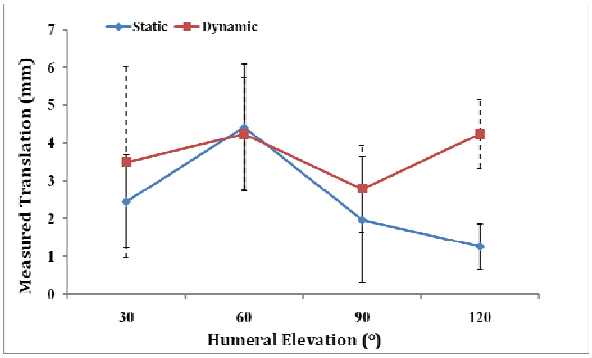

Fig. 2. Measured superior humeral head translation of static and dynamic trial.

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