INTRODUCTION

Efficient and coordinated scapular kinematics are essential for safe and injury free overhead movements of the upper extremity and dynamic joint stability of the shoulder complex.

Altered scapular kinematics have been observed in groups with shoulder injury, such as rotator cuff impingement, and is significantly affected following fatigue. Quantification of scapular kinematics is necessary to prospectively predict risk of injury and determine the efficacy of injury prevention interventions.

Currently, the most common methodology to test scapular kinematics is with the use of electromagnetic tracking technology (EMT). Unfortunately, EMT has some inherent disadvantages as most devices require the subject to be tethered to the data collection computer which prevents testing of high speed, dynamic sport movements.

Video-based motion analysis offers greater freedom of movement and newer cameras are capable of the higher sampling frequency that is necessary for measurement of high speed movements. Additionally, newer cameras utilized in video-based motion analysis have been significantly improved providing greater resolution and greater capability to visualize and distinguish multiple small markers in a concentrated area. Therefore the purpose of this study was to validate the use of video-based motion analysis to capture three-dimensional (3D) scapular kinematics.

To validate the use of video-based motion analysis to capture three-dimensional (3D) scapular kinematics. If validated, this would provide researchers with greater flexibility to quantify scapular kinematics.

EXPERIMENTAL DESIGN AND METHODS

DESIGN

A validation study comparing a video-based motion analysis (VMA) technique against a dynamic stereo x-ray (DSX) technique, which is a previously validated gold-standard technology.

SUBJECTS

Five adult male subjects (Age=27.8±6.9 yrs; Ht=1.81±4.9 m; Wt=77.9±9.5 kg)

EQUIPMENT

The VMA system included eight high-speed infrared cameras (Vicon Motion Systems, Inc., Centennial, CO).

The DSX system included two 100kW pulsed X-ray generator (EMD Technologies, Quebec), two 40cm image intensifiers (Neuilly-sur-Seine, France), and two high-speed cameras (Vision Research, Wayne, NJ).

Both systems were synchronized with a sampling rate of 50Hz.

PROCEDURES

3D bone models of the scapula and humerus were CT-scanned and reconstructed for each subject. Anatomical landmarks were marked on the models.

Reflective markers were attached to anatomical landmarks on the trunk, arms, and scapulae following the ISB recommendations. A three-marker triad was attached to the flat portion of each acromion.

After a static capture by the VMA system, the markers attached to the scapular anatomical landmarks were removed.

Subjects performed scapular-plane humeral elevation and depression following a metronome at the pace of 2 seconds per cycle.

Kinematic data were captured by the two systems simultaneously.

Scapular kinematics calculated based on the ISB recommendations:

For the VMA system, the virtual trajectories of the scapular landmarks were estimated based on the markers on the triads.

For the DSX system, the CT bone models were matched to the captured X-ray video and the trajectories of the anatomical landmarks were therefore retrieved.

RESULTS

Measurement bias and dynamic precision are presented in Table 1.

The Pearson product-moment correlations were moderate to high (Table 2).

Group averages for entire movement range are presented in Figure 3.

| Table 1. Measurement Bias and Dynamic Precision (mean±SD) |
|---------------------------------|----------------|
| Protraction/Retraction           | -3.95±5.41     |
| Medial/Lateral Rotation          | -9.88±3.43     |
| Anterior/Posterior Tilt          | 3.93±6.28      |

| Table 2. Correlation Coefficients between the VMA and DSX |
|---------------------------------|----------------|
| Protraction/Retraction          | 0.73±0.147     |
| Medial/Lateral Rotation         | 0.95±0.034     |
| Anterior/Posterior Tilt         | 0.70±0.437     |

SUMMARY AND CONCLUSIONS

- The statistical analyses revealed high correlations within subject and for the group averages.
- Based on the total range of motion for each movement, the measurement bias and precision appears acceptable.
- Although further analysis is necessary to examine the other humeral movements, this preliminary analysis demonstrates that video-based motion analysis is a valid technique to quantify 3D scapular kinematics.