USE OF A DIGITAL INCLINOMETER TO ASSESS SCAPULAR UPWARD ROTATION: A RELIABILITY AND VALIDITY STUDY

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INTRODUCTION

Evidence exists that the scapula plays a role in shoulder pathology. However, clinical evaluation of patients with shoulder dysfunction often fails to include an objective assessment of scapular motion. The purpose of this study was to examine the reliability and validity of an inexpensive inclinometer to assess scapular upward rotation during humeral elevation in the scapular plane.

REVIEW AND THEORY

Scapulohumeral rhythm is defined as the coordinated glenohumeral and scapulothoracic movements during arm elevation. Scapular upward rotation occurs simultaneously with humeral elevation. Changes in the scapulohumeral rhythm are associated with various shoulder pathologies (Warner et al., 1992).

Researchers have been studying motion of the shoulder complex for more than 50 years. Early research performed two-dimensional (2-D) static analysis using various methods (Poppen, Walker, 1976). More recent studies used three-dimensional (3-D) static and dynamic motion analysis (McQuade, Smidt, 1998). However, these methods are impractical for use in clinical research and practice.

Recently, 2-D clinical methods have been used to assess scapular positions (Gibson et al., 1995). None of the 2-D clinical methods 1) assesses scapular upward rotation or 2) has been validated with a 3-D motion analysis system.

PROCEDURES

Proposed New Method: A Pro 360 digital inclinometer (Macklanburg Duncan, Oklahoma City, OK) was used for 2-D static measurements of scapular upward rotation during humeral elevation. The instrument was modified by adding two wooden locator rods to its inferior surface. These rods had Y shaped ends, which were placed over the root of the scapular spine and the posterolateral acromion during each measurement session. A guide angled 40° from the frontal plane was used to insure positioning of the arm in the scapular plane.

Thirty-nine subjects with (n=16) and without (n=23) shoulder pathology participated in the study.

Reliability: The Pro 360 was used to assess scapular upward rotation positions with the arm at rest, 60°, 90°, and 120° of humeral elevation in the scapular plane. In this study, we assessed seventy-five scapulae for reliability. Intra-rater reliability was determined using repeated measurements from the Pro 360 taken at each static arm position, 10 minutes apart.

Validity: 3-D measurements of scapular
motion were taken using a Polhemus 3Space FasTrak (Polhemus 3Space FasTrak, Colchester, VT). Karduna and associates previously developed a methodology for using this system to accurately measure 3-D scapular kinematics (Karduna et al., 1998). Scapular upward rotation data were statically collected with the arm at rest, 60°, 90°, and 120° of humeral elevation in the scapular plane. Data were also collected during dynamic humeral elevation in the scapular plane.

We assessed fifty-nine scapulae for validity. Validity was determined, at the four arm positions, using the following comparisons: (1) Pro 360 and Polhemus under static arm conditions and (2) Pro 360 and Polhemus during dynamic arm elevation in the scapular plane (see Figure 1).

![Figure 1: Concurrent measurements of scapular upward rotation using the Pro 360 and Polhemus with the arm held at 90°.](image)

### RESULTS AND DISCUSSION

Intra-class correlation coefficients [ICC 3,1], shown in Table 1, indicated excellent reliability. Our results compared favorably with previous literature regarding intra-rater reliability of assessing scapular positions using 2-D methods (Gibson et al., 1995). Pearson product-moment correlation coefficients were used to assess validity and are shown in Table 1. Concurrent validity was excellent comparing scapular positions using the Pro 360 and the Polhemus under static conditions. Validity was good comparing the Pro 360 and the Polhemus during dynamic arm elevation.

### SUMMARY

This is the first study to address validation of a simple, clinical measurement with a 3-D measurement system. The 2-D method described is quick and easy to perform. It is plausible for clinical use and may provide useful objective data regarding scapular motion, which is presently unavailable to the clinician. Future research should address inter-rater reliability and between groups comparisons using a digital inclinometer.

### Table 1: Results of reliability and validity testing at all four arm positions.

<table>
<thead>
<tr>
<th>Arm Position</th>
<th>Reliability</th>
<th>Validity (1)</th>
<th>Validity (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICC (3,1)</td>
<td>r</td>
<td>r</td>
<td></td>
</tr>
<tr>
<td>rest</td>
<td>0.90</td>
<td>0.85*</td>
<td>0.68*</td>
</tr>
<tr>
<td>60°</td>
<td>0.90</td>
<td>0.86*</td>
<td>0.65*</td>
</tr>
<tr>
<td>90°</td>
<td>0.93</td>
<td>0.85*</td>
<td>0.67*</td>
</tr>
<tr>
<td>120°</td>
<td>0.94</td>
<td>0.91*</td>
<td>0.71*</td>
</tr>
</tbody>
</table>

* p < 0.001

### REFERENCES


