Low Reliability Found Between Motion Capture Sensors and Standard Goniometry: A Cross-Sectional Analysis

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INTRODUCTION: Shoulder range of motion (ROM) assessment is a crucial aspect in the clinical evaluation of shoulder pathology and rehabilitation following shoulder surgery. Currently, the standard handheld goniometer is still the gold standard for measuring shoulder ROM. However, variability in user skill and experience has been shown to affect measurement results, and some argue that goniometry is inconvenient and can be unreliable. The purpose of this study was to compare the effectiveness of motion capture sensors and goniometry for measuring shoulder ROM. We hypothesized that motion sensors would show moderate reliability in measuring shoulder ROM when compared to standard goniometry.

METHODS: This was a cross-sectional study that analyzed shoulder ROM for patients at a single fellowship-trained orthopaedic surgeon's clinic as part of a standard office visit. Each sensor and goniometry ROM assessment was blinded to the other assessor. Inclusion criteria included patients with motion sensor and goniometer measurements taken during a preoperative or postoperative clinic visit. Patients were excluded if they could not adequately complete the ROM measurements due to pain or discomfort. Active ROM measurements included right and left forward flexion, abduction, and external rotation. ROM at the patient's maximum end-range of motion was recorded. Interclass Correlation Coefficient (ICC) was used to evaluate the relationship between motion sensor and goniometer measurements.

RESULTS SECTION: There were 30 patients included in ROM testing, with an average age of 45.1 years (range: 17-78 years). Overall, sixteen (53.3%) patients presented with rotator cuff tears, seven patients (23.3%) presented with labral tears, two patients (6.7%) presented with concomitant Hill-Sachs and Bankart lesions, two patients (6.7%) presented with adhesive capsulitis, two patients (6.7%) presented for a standard postoperative wellness visit, and one patient (3.3%) presented with glenohumeral osteoarthritis. Goniometer measurements and sensor measurements for forward flexion had moderate reliability for the operative shoulder (ICC = 0.59) and poor reliability for the nonoperative shoulder (ICC=0.08). For abduction, there was poor reliability for the operative shoulder (ICC=0.39), and poor reliability for the nonoperative shoulder (ICC=0.01). Finally, for external rotation, there was moderate reliability for the operative shoulder (ICC=0.60) and poor reliability for the nonoperative shoulder (ICC = 0.04).

DISCUSSION: The results of this study revealed that upper-arm motion sensors are not a reliable tool in measuring shoulder ROM. The observed inter-rater reliability between the motion sensors and goniometry measurements revealed poor reliability when measuring nonoperative forward flexion, operative and nonoperative abduction, and nonoperative external rotation. Moderate reliability was observed in operative forward flexion and operative external rotation. While motion capture sensors may not be a reliable surrogate to measure ROM, the value of the sensor may be in monitoring compliance to therapy and ROM exercises at home. Further work may be necessary to advance the technology so that motion capture sensors can reliability measure ROM in a clinical setting.

SIGNIFICANCE/CLINICAL RELEVANCE: (1-2 sentences): Consistent shoulder range of motion assessment is a crucial aspect of clinical evaluation of shoulder pathology and rehabilitation. This study evaluates the reliability of the standard goniometer compared to motion capture sensors, which allows surgeons to understand the clinical consistency and dependability of these range of motion tools in order to determine their ideal use in practice.