# Reliability Comparison of Virtual Versus In-Person Goniometric Measurements of the Upper Extremity

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**BACKGROUND:** One of the primary components of the musculoskeletal physical examination is the assessment of joint and limb motion. The recent popularity of virtual healthcare has forced clinicians to modify or eliminate certain hands-on parts of the musculoskeletal evaluation such as range of motion. While clinicians have been shown to have acceptable to excellent levels of intra and inter-rater reliability using goniometers, virtual examinations require the clinician to use 2-dimensional landmarks to document motion. This raises concerns about the accuracy of the measurement.

**PURPOSE:** The purpose of this study was to determine if similar goniometric measurements of the upper extremity could be obtained in-person and virtually. Design and Setting: Reliability study; classroom setting Patients: Publicly recruited sample over the age of 18 with no upper extremity injuries.

**METHOD:** Subjects completed a consent form, demographic information, and the Disabilities of the Arm, Shoulder, and Hand (DASH). The dominate arm was used for testing. Each subject was tested in a standing position facing sideways to visualize the landmarks for goniometer placement. Flexion and extension of the shoulder, elbow and wrist were measured. For elbow and wrist measures, the humerus was in line with the trunk. Prior to performing the in-person goniometric measurements for each joint, an image was captured of each pre-determined joint position using a mobile device with a camera (iPad Air 2, Apple, Inc, Cupertino, CA).This image represented the screenshot on a virtual platform. Four clinicians performed in-person range of motion measurements twice during the same session on each subject. To reduce the potential for recording bias by the team member performing the measurements, the goniometer dial was covered with paper and a second team member read and recorded the range of motion to the nearest degree mark. The following week clinicians measured the virtual images using the same goniometric techniques. This step also utilized 2 team members, one member performing the measurement for each image and another member reading the goniometer. The average of the two trials was calculated for both in-person and virtual sessions.

**RESULTS:** The inter-rater reliability for five of the six in-person and virtual measurements were classified as excellent, respectively (ICC≥0.81; ICC≥0.78 ). In-person wrist extension was classified as good (ICC=0.60). Virtual wrist flexion was classified as good (ICC=0.65). The intra-rater reliability for the individual clinicians were between good and excellent for the in-person measurements (range: 0.61-0.96) and virtual measurements (range: 0.72-0.97). When examining the individual measurement results, the ICCs for both in-person (ICC≥0.84) and virtual (ICC≥0.93) shoulder extension and in-person (ICC≥0.89) and virtual (ICC≥0.94) elbow extension were all classified as excellent. There were a greater number of excellent ICC values for the virtual measurements (90%) compared to the in-person measurements (70%). When combining all clinician measurements, there were statistically significant differences between in-person and virtual sessions for 5 of the 6 measurements (p≤0.006). Only the measurement of elbow extension did not differ between sessions (p=0.966).

**CONCLUSION:** Virtual assessment compared to goniometric measurements showed good to excellent inter- and intra-rater reliabilities (ICC > 0.60), which suggests clinicians can utilize goniometry on a virtual platform. Capturing screenshots during a virtual exam to measure range of motion is recommended and is supported by the higher percentage of ICCs. Impact Statement: The results suggest goniometry can be used in a virtual treatment session.

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