Inter-rater and intra-rater reliability of finger goniometry measured from screenshots taken via video consultation

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ABSTRACT

The purpose of this study was to assess the intra- and inter-rater reliability of using screenshots and handheld manual goniometers to assess range of finger movements during video consultations. Twenty-seven hand therapists measured finger joint angles from four different screenshots using two different goniometers. Results were compared within and between participants using the intraclass correlation coefficient (ICC). The ICC grading for both intra- and inter-rater reliability was moderate to excellent for all joints and both goniometers,. Clinicians can measure finger joint angles from a screenshot with good reliability. The protocol used in this study can be used in remote video consultations as a no-cost substitute for in-person goniometry.

Level of evidence: II

INTRODUCTION

Goniometry is an integral assessment tool used in the diagnostic process and to measure the effects of hand surgery and hand therapy interventions (Burr et al., 2003; Gibson, 2015; Groth and Ehretsman, 2001). The use of hand held, manual finger goniometers has been shown to have high inter- and intra-rater reliability (Gibson, 2015; Kooij et al., 2017).

In 2020, the COVID-19 pandemic led to a rapid shift in the delivery of hospital appointments, with face-to-face appointments being replaced with video appointments. Some patient presentations will always need to be seen face-to-face for at least part of their treatment owing to their complexity, acuity or need for manual treatments, but many hand and upper limb assessments may be well suited to video consultations. The entire hand and upper limb can be easily visualized on screen with a webcam or phone-mounted camera and for many presentations there is a preference for active self-management strategies rather than “hands-on” passive techniques (Hutting et al., 2019). Furthermore, most of the United Kingdom and European households have internet access and connected devices (European Commission., 2021; Statista, 2020). However, for both patients and clinicians, there are barriers to virtual consultations. These include access to, and ability to use, the technology; space required to run a virtual consultation; desire for human contact; the perception that face-to-face is required for adequate assessment of a complex presentation; and a level of anxiety that patients report around seeing themselves on screen (Gilbert et al., 2021). Additionally, many of the assessment tools that are relied upon in the clinic need adaptation for the virtual setting (Nest et al., 2020).

Previous studies have found that finger, wrist and elbow joint angles can be measured from photographs using computer software with good reliability (Chen et al., 2021; Meislin et al., 2016; Wagner et al., 2018; Zhao et al., 2020). These studies describe patients and carers being trained to take photographs of their limbs and to send them to the health professionals to be assessed. The health professionals then use software programs to measure joint angles.

To meet the need for range of movement assessments for patients being reviewed using video consultations, hand therapists at Guy's and St Thomas' NHS Foundation Trust, a large tertiary referral hospital in the United Kingdom, started to use manual goniometers to measure finger joint angles from screenshots taken during video consultations. This was considered acceptable for both patients and clinicians. Unlike using photographs taken by patients and carers, the screenshot measurements could be made contemporaneously and did not require either patient or carer training or additional software. The use of screenshots and manual goniometer measurements was adopted out of necessity and to the best of our knowledge, there are no existing data reporting the reliability of this method of assessment. The aim of this study was to assess the intra- and inter-rater reliability of using screenshots and handheld manual goniometers to assess range of finger movement.

METHODS

Three volunteer 'patients' had all of the fingers of one hand immobilized in varying degrees of mid-range flexion in a custom orthosis. Two authors (DJ and RB) simulated a video consultation with each volunteer using the same process as with patients. The appointment was hosted on the NHS Attend Anywhere platform and volunteers connected using their own mobile devices and mobile network data. The lead author (DJ) connected to the appointment on a desktop computer using the hospital internet and gave verbal prompts to guide the volunteers to orientate their hand so that a lateral view of the target finger was achieved, and the dorsum of the finger was clearly visible. Screenshot images were taken using the operating system default screen capture tool (Figure 1). Four screenshot images were taken in total (one image of volunteer 1, two images of volunteer 2 and one image of volunteer 3) with each image focused on a single finger (index, middle, ring and little finger). The volunteers were non-clinical members of the hand unit team.

The joints of each of the individual target fingers were also measured in-person by three hand therapists while the volunteers were still wearing the custom orthoses. These measures were taken using a JAMAR® Finger/Toe Goniometer (Performance Health International Ltd, Warrenville, Illinois, United States of America) and were used to calculate the 'true' position of each finger joint for comparison with the virtual measures.

To assess inter-rater reliability, hand therapists within the team were shown four screenshot images (one of each finger) and asked to measure the metacarpophalangeal (MCP), proximal interphalangeal (PIP) and distal interphalangeal (DIP) joint angles. Therapists followed a written protocol that reflected how range of movement assessments are carried out in practice. A manual goniometer was placed against the screen of their computer or tablet and the goniometer arms were aligned with the dorsum of the finger. Figure 2 shows images that were included in the written protocol to illustrate the assessment method. Two different types of goniometer were tested: the JAMAR® Clear Goniometer (Performance Health International Ltd, Warrenville, Illinois, United States of America) and the JAMAR® Finger/Toe Goniometer (Figure 3).

To assess intra-rater reliability, each assessment was repeated for each type of goniometer, with a 2-week period between measures to prevent recall of the previous measurements. Measurements were submitted via an online portal (Google Forms) and therapists did not have access to their previous measurements once submitted.

Data analysis

Both in-person and virtual joint measurements were summarized using descriptive statistics. Data were normally distributed (consistency of mean and median) and were reported as the mean and standard deviation (SD) for each joint. Reliability was calculated using the intraclass correlation coefficient (ICC) with 95% confidence intervals (CIs). Inter-rater reliability was assessed using a two-way random effects model with consistency of agreement, and intra-rater reliability was assessed using a two-way mixed effects model with absolute agreement (Koo and Li, 2016). The ICC results were graded as poor (<0.5), moderate (0.5-0.75), good (0.75-0.9) and excellent (>0.9) (Koo and Li, 2016).

In a sensitivity analysis, mean and SD measures for each joint, and the ICC and 95% CIs were compared for in-person and virtual measurements.

Approvals and governance

The study was approved by the Guy’s and St Thomas’ NHS Foundation Trust Occupational Therapy Clinical Audit Team (Project number 12308).

RESULTS

Participants

Twenty-seven hand therapists took part in the study. Of these, 12 were occupational therapists and 15 were physiotherapists. Three therapists had been working in hand therapy for less than 1 year, nine for 1-5 years, another nine for 5-10 years, and six for more than 10 years. All therapists were included in the inter-rater reliability analysis. For the intra-rater reliability assessment, 25 therapists completed repeated measures with the finger/toe goniometer and 24 with the clear goniometer.

Sensitivity analysis

The mean and SD of the in-person and virtual measures for each joint are presented in Table 1. The SD for virtual measurement methods were similar to those of the in-person measurement methods, indicating comparable variability between the virtual assessment and the standard in-person method. Comparison of the mean in-person measurements and virtual measurements shows no systematic over- or underestimation of joint angle. However, individual measures of the DIP joint appear to be consistently underestimated via in-person measurement, while MCP joint measures appear to be consistently overestimated.

Inter-rater reliability

Inter-rater reliability ICC with 95% CIs are presented in Table 2. The ICC grading was moderate to excellent for in-person and virtual measurement methods, for all joints and both goniometers.

Intra-rater reliability

Intra-rater reliability ICC with 95% CIs are presented in Table 3. The ICC grading was moderate to excellent for all joints and both goniometers.

Summary data for virtual and in-person measurements of each joint and goniometer are available through the Open Science Framework (Johnson et al., 2022).

DISCUSSION

The ICC for all joints combined indicated excellent inter- and intra-rater reliability, which supports the use of this technique to measure finger joint angle during video consultations.

However, the finger/toe goniometer had only moderate reliability for MCP joint measures. This could be due to a mismatch between the long metacarpal ray and short mobile arm. The clear goniometer had only moderate reliability for DIP joint measures, potentially due to the long mobile arm and short distal phalanx ray. These findings suggest that use of a clear goniometer for the MCP joint and the finger/toe goniometer for the DIP joint may result in more reliable measurements in practice.

The authors feel that the two-dimensional (flat) design of the clear goniometer may make it better suited for range of movement assessment using screenshot images.

A broad range of hand therapy experience was reflected in the large sample of assessors. This reflects how goniometry applies in clinical practice, with patient care often being shared in a multidisciplinary team of varying skill levels.

Although it was the COVID-19 pandemic that stimulated a rapid shift to provide hand surgery and hand therapy appointments via online platforms, the NHS long term plan stipulated that technological solutions including telehealth consultations would replace one third of face-to-face outpatient appointments by 2023 (NHS, 2019). Video appointments have the potential to offer cost-savings for patients and healthcare services and may improve accessibility to specialist services by reducing the travel burden for patients. In addition, there is an environmental benefit of reducing transport requirements.

Previous studies have analysed the reliability of taking goniometric measurements from photographs of fingers and elbows (Chen et al., 2021; Meislin et al., 2016; Zhao et al., 2020). These studies required a patient or caregiver to be trained to use a smartphone camera to take the photographs, which were later measured by a health professional using software. In practice, the transfer and storage of files creates extra steps for patients and healthcare workers. They also raise issues of data security, and necessitate the creation of a new procedure, which in many settings would require separate consent forms. Additionally, using new software to take the measurements incurs costs and training. The method described above bypasses these issues. If screenshots are taken using the *Snipping Tool* program in Windows, or similar, and measurements are taken in-session then no images are saved. Patients are guided into position with verbal and visual prompts for the therapist to take the screenshot, there are no extra steps or training. The goniometers that were used are commonly available in most hand units and the protocol is sufficiently similar to standard in-person measurement that most will find it intuitive.

There are some limitations to this study. The method used depends on the conversion of a three-dimensional finger into a two-dimensional picture and as such introduces the possibility of parallax error. The parallax effect is the change in relative position of objects when viewed from different angles. In photography, angles can appear larger or smaller depending on the position of the lens in relation to the subject. Analysis of our data shows that this may have occurred in our study. For example, the mean of the virtual finger/toe and clear goniometer measurements of DIP joint of the index finger shows that the angle appears overestimated compared to in-person measurements. Similarly, the MCP joint angle of the little finger appears underestimated by the virtual goniometers. With only a small sample of in-person measures, it is not possible explore this finding in greater depth. However, this does highlight the importance of positioning the hand and target finger when taking screenshots so that a ‘true’ lateral view of the joint is achieved. Future work should involve collaboration with radiography colleagues to develop a standardized protocol to minimize the potential effect of parallax error.

During video consultations, it can be difficult to direct the patient to align their hand with their camera in order to achieve an acceptable lateral view of the finger. This can be complicated by dressings, pain and swelling from trauma, uninvolved fingers obstructing the camera, low lighting, poor internet connection and other patient factors including whether or not patients are adept at using the required technology. Our study focused on an initial assessment of intra- and inter-rater reliability and did not look at these factors.

Our study did not assess measurements of the thumb joint angles as the Kapandji score (Kapandji, 1986) was deemed to be a reliable method to assess for thumb opposition and flexion (Jha et al., 2016) and could easily be used in the telehealth setting. All participants were hand therapists which may limit generalizability of results to other healthcare professionals. The plan for the study was for participants take repeat measures 7-14 days apart to minimize recall of the previous measurements. However, in practice, owing to workplace factors, the median time between individual participants’ measurements was 21 days (range 0-60 days). Six individuals completed the repeated measures with a gap of less than 7 days, which has the potential to affect the intra-rater reliability findings, however there was similar variation in repeated measures for these individuals and the rest of the participants.

Clinicians can measure finger joint angles from a screenshot with good reliability using either the standard finger/toe goniometer and the clear goniometer. The protocol used in this study can be used in remote video consultations as a no-cost substitute for in-person goniometry. Development of a standardized protocol to ensure optimal orthogonal views of the joints being measured may improve the accuracy of this method.

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Figure Legends

Figure 1. The screenshot of a volunteer's hand immobilized in the custom-made orthosis, focusing on the middle finger for measurement

Figure 2. Examples from the measurement protocol illustrating the placement of the manual goniometers against an image of a "patient's" hand

Figure 3.: A) JAMAR® Clear Goniometer; B) JAMAR® Finger/Toe Goniometer