Reliability of handgrip strength test in elderly subjects with unilateral thumb carpometacarpal osteoarthritis

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Abstract

Background The grip strength test is widely used; however, little has been investigated about its reliability when used in elderly with subjects thumb carpometacarpal (CMC) osteoarthritis (OA). The purpose of this study was to examine the test–retest reliability of the grip strength test in elderly subjects with thumb CMC OA.

Methods A total of 78 patients with unilateral thumb CMC OA, 84.6 % female (mean±SD age 83±5 years), were recruited. Each patient performed three pain free maximal isometric contractions on each hand in two occasions, 1 week apart. Intraclass correlation coefficient (ICC), standard error of measurement (SEM), and 95 % limits of agreement (LOA) were calculated.

Results Test–retest reliability was excellent for side affected (ICC=0.947; $p=0.001$) and contralateral (ICC=0.96; $p=0.001$) thumb CMC OA.

Conclusions The present results indicate that maximum handgrip strength can be measured reliably, using the Jamar hand dynamometer, in patients with thumb CMC OA, which enables its use in research and in the clinic to determine the effect of interventions on improving grip.

Keywords Test–retest · Thumb · Carpometacarpal osteoarthritis · Grip strength

Introduction

The carpometacarpal (CMC) joint of the thumb plays a vital role in optimal hand function. The thumb CMC joint is frequently affected by osteoarthritis (OA), a degenerative condition that can result in deterioration of the joint surfaces [27, 25]. Individuals with CMC joint OA have decreased grip strength that impacts hand function and their ability to perform resistive grip tasks [8, 14]. A strong positive correlation has been found between the variables of grip force control and some parameters of hand function and dexterity in patients with hand OA [17].

To enable the clinician to correctly interpret whether or not a genuine and true change of grip strength has occurred, the tool used to assess grip must be tested and found reliable and valid for use for that patient population [21]. The reliability of measurement can be influenced by several factors such as pain level and loss of normal mobility of the fingers or thumb after injury or disease process [11]. The experience of the examiner also might influence the measurement accuracy. However, studies that examine the impact of pain and disease process on grip strength for patients with hand degenerative conditions are scarce. There are several studies that have examined the reliability of the handgrip strength test in subjects with hand injuries [20, 3] and in people without impairments of the hand [15, 10, 19]. Several studies have evaluated the effect of

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therapeutic interventions on joint function in patients with CMC OA [9, 28, 29, 24, 26]. Villafañe et al. found high intrarater reliability when assessing grip strength test in the non-involved hand using the Jamar dynamometer [24, 26]. Although the reliability of pinch strength testing of patients with CMC OA has been reported previously [23], no previous study, to our knowledge, has investigated the reliability of handgrip strength testing for use in thumb CMC OA patients.

The reliability of the measurement of grip strength is essential for satisfactory data collection for consistent interpretation of the results. In particular, test–retest reliability is clinically important for correct assessment of follow-up results. Good test–retest reliability enables comparisons to be made over a period of time. Reliable results allow the professional to reach conclusions that are minimally affected by external factors, thereby reducing the chances of error. Therefore, the purpose of this study was to examine the test–retest reliability of the handgrip strength test in elderly subjects with unilateral thumb CMC OA.

Subjects and Methods

A convenience sample of 78 elderly subjects from 70 to 90 years old were recruited for the study from January 2013 to September 2013. Subjects were both male and female and had the medical diagnoses of unilateral thumb CMC OA. All subjects were right-hand dominant. To reach the sample size, the sample calculation was performed based on a priori power calculation on other studies of CMC OA patients, to detect a difference in reliability of 0.98 [24] and 0.72 [29] at 80 % power and a 5 % level of significance. The calculation generated a sample size of 60 individuals. Informed consent was obtained from all participants, and all procedures were conducted according to the Declaration of Helsinki. Patients underwent subjective and physical examination conducted by a therapist with 12 years of experience in treating musculoskeletal disorders. Participants were included if they exhibited a stage III–IV thumb CMC OA in the dominant hand confirmed radiographically according to the Eaton-Littler-Burton classification [12]. The combination of radiological and clinical findings has been recommended for making a more accurate diagnosis of thumb CMC OA [30]. Clinical findings may include reported pain at the CMC joint or a positive grind test. Exclusion criteria were as follows: previous treatment intervention with surgery in the hand or the forearm; corticosteroid injection or any physical therapy intervention within 6 months before the study; multiple pain diagnoses of the upper extremity, e.g., carpal tunnel syndrome, de Quervain's tenosynovitis, shoulder pathology, and cervical radiculopathy; evidence of systemic illness (rheumatoid arthritis, psoriatic arthritis, systemic lupus erythematosus); fibromyalgia syndrome; complex regional pain

syndrome; any degenerative or non-degenerative neurological conditions where pain perception can be altered; presence of any symptom in the non-dominant hand; and evidence of radiographic alterations at the first CMC joint in the non-dominant hand [4, 5].

The participants performed a standardized warm-up that consisted of two to three preliminary trials of the test procedure for familiarization with the procedure and instrument used during the procedure. Testing took place between the hours of 9:00 am and 11:30 am. The subjects were given the opportunity to handle the dynamometer before measurement recording. A portable JAMAR Hydraulic Hand Dynamometer (Fabrication Enterprises, Inc.) was used for handgrip strength measurement. The test was performed in the sitting position with the shoulder of tested arm adducted to the side, the elbow flexed at 90°, and the forearm and wrist were set in neutral position [29]. The testing protocol consisted of three pain-free maximal isometric contractions for 3 s, on both hands, with a 1-min pause between measurements. Patients were instructed to squeeze the dynamometer as firmly as possible without eliciting pain. Pain was assessed using the verbal analogue scale. If the subject reported pain during testing, the test was re-administered with instruction to stop squeezing before the onset of pain. Each patient performed three pain-free maximal isometric contractions on each hand on two occasions, one week apart. The mean of these three trials was used for analysis. The trial was designed according to the CONSORT publishing guidelines [13].

Statistical Analysis

Data were analyzed using SPSS version 20.0 (SPSS Inc, Chicago, IL, USA). The results are expressed as means, standard deviations, and/or 95 % confidence intervals. Test–retest data was analyzed using the intraclass correlation coefficient (ICC). ICC values equal or greater than 0.80 are considered high. We calculated ICC for single measures using a two-way random effect model of absolute agreement for the computation of ICC. In order to assess the absolute reliability, the standard error of measurement (SEM) and the 95 % limits of agreement (LOA) were calculated by means of the following equation: $SEM = SD \times \sqrt{1 - ICC}$ and $LOA = \text{inter-trials mean difference} \pm 1.96 \text{ SD of the between trials difference}$. The SEM expresses measurement error in the same units as the original measurement, and it is not influenced by variability among patients. The inter-trials agreement was also examined graphically by plotting the difference between test and retest against their mean, according to the Bland and Altman approach to calculate LOA [1]. Agreement between two methods of measurement can be inappropriately assessed using the correlation that assesses the relationship of the measurements on a straight line. The LOA calculation plots the differences between test and retest against their mean on both a horizontal and vertical

axis. The plot enables a visual inspection of the association between the difference in measurements and the magnitude of grip strength. The statistical analysis was conducted at a 95 % confidence level, and a $p < 0.05$ was considered statistically significant. ANOVA analysis was performed to determine differences between test and retest handgrip strength values.

Results

Seventy-eight elderly subjects (66 % females), mean age $\pm$ SD 82.9 ± 5.5 years, met all the inclusion criteria and agreed to participate. All subjects exhibited a stage IV thumb CMC OA in the dominant hand (Eaton-Littler-Burton classification). No participants dropped out during the different phases of the study, and no adverse effects were detected after the application of the measurement. None of the participants began drug therapy during the course of the study. The results indicated non-significant differences between test and retest handgrip strength values. The relative reliability between test and retest was very high. Test–retest reliability was excellent for the CMC OA-affected right hand (ICC=0.947; $p=0.001$) and contralateral left hand (ICC=0.96; $p=0.001$). The absolute reliability (SEM and LOA) was good. The mean absolute difference between test and retest was 0.61 and 0.54 kg for the affected right hand and contralateral left hand, respectively. The 95 % limits of agreement ranged from -2.54 to 2.71 kg for the affected hand and from -2.44 to 2.27 kg for the contralateral hand (Fig. 1 and Table 1). The ANOVA analysis found no statistically significant differences between test and retest grip strength values.

Discussion

In our study, high ICC was found for the reliability of grip strength measurements for both affected and contralateral hands in subjects with CMC OA. However, there were no significant differences, in both absolute and relative handgrip strength between affected and unaffected hands. The results suggest that hand-held dynamometry can be a reliable assessment technique when practiced by a single experienced tester. This supports findings of a prior study that reported that a single examiner could reliably use a dynamometer when assessing grip on neurologically impaired individuals [2]. Not all studies use a single tester for all measurements; future studies should address the inter-rater reliability of grip testing. Future work should concentrate on measuring the dynamic strength of individuals with CMC OA because dynamic strength is used by individuals' everyday when performing activities of daily living such as opening jars and food packaging. Pain can also affect grip strength and testing reliability.

Perhaps this study's subjects grip strength would have been greater if they were allowed to squeeze the dynamometer into a painful range. The patients performed grip strength testing on two occasions, 1 week apart in this study; perhaps, 1 week was not a long-enough period and strength should have been assessed at 1 month and 6 months as well.

These findings agree with the work of Coldham et al. [6] who demonstrated excellent test–retest reliability for the evaluation grip strength in symptomatic subjects and with Stratford et al. [22] and Nitschke et al. [16] for the reliability of pain-free grip strength in populations with painful conditions. The SEMs in this study were small, ranging from 0.54 kg for grip with the right hand to 0.64 kg for grip with the left hand. Clinically, this implies that a change as small as ± 1.2 kg (2 SEM) is indicative of a true change in grip strength for patients with CMC OA [18]. A change smaller than the standard error of measurement (SEM) is likely to be the result of measurement error rather than a true observed change. Patients achieving a difference in grip of at least one standard error of measurement (0.54 kg right, 0.64 kg left) may help the clinician determine that a patient has achieved a minimal clinically important difference [7].

In an attempt to control known risk of errors, we followed the American Society for Hand Therapists' standardized position [23]. Comparison of the reliability results between this and other studies can only be made where the sample size and subject demographics are similar. Results may vary in a population of patients with different stages of CMC OA or with subjects that have differing degree of pain. This study used a short retest interval of 1 min for recovery from possible fatigue. The high degree of reliability and low SEMs found in this study may be affected if testing with an alternative rest interval.

While clinical tests are important physical measures, it is also important to incorporate patients' perceptions of their OA symptoms as well as changes in those symptoms [22]. We recommend that clinicians incorporate a patient-centered outcome measure in their clinical practice to assess change from the patient's perspective.

There are some limitations to this study. First, participants were elderly subjects with stage IV thumb CMC OA and, undoubtedly, they were not representative of the entire population that would be measured in clinical practice. Additional studies are needed to examine grip strength among other age groups and other stages of CMC OA. Additional studies are needed to examine these relationships among other age groups and other stages of CMC OA. We also did not recruit participants for the study, but rather used a sample of convenience. Another limitation is that the purpose of this study was to measure the test–retest reliability of the grip strength test in elderly subjects with unilateral thumb CMC OA; however, this is not a comprehensive measure of hand function.

Fig. 1 Bland–Altman plots of the handgrip strength test for **a** affected right and **b** contralateral left hand in subjects with thumb CMC OA. The *central line* characterizes the mean difference between test and retest values; the *upper* and *lower lines* characterize the upper and lower 95 % limits of agreement (LOA inter-trials mean difference ± 1.96 SD of the inter-trials difference), respectively

Table 1 Test and retest values, and index of relative and absolute reliability of handgrip strength in patients with thumb CMC OA

	Test (kg)	Retest (kg)	Bias (kg)	ICC (95 % CI)	95 % LOA (kg)		SEM (kg)
					Lower	Upper	
Affected right hand	9.38 $\pm$ 4.14	9.30 $\pm$ 3.84	0.083	0.94 (0.91; 0.96)	-2.543	2.709	0.61
Contralateral left hand	8.17 $\pm$ 4.26	8.26 $\pm$ 4.20	-0.083	0.96 (0.94; 0.97)	-2.439	2.272	0.54

Data are expressed as means $\pm$ standard deviation

Bias difference between test and retest, *ICC* intraclass correlation coefficient; *95 % CI* 95 % confidence interval, *95 % LOA* 95 % limits of agreement, *SEM* standard error of measurement

The results of our study indicate that reliable grip strength assessment can be obtained with the Jamar dynamometer if the Jamar is calibrated properly and standardized testing procedures are followed. Maximum handgrip strength can be measured reliably, using the Jamar hand dynamometer, in patients with thumb CMC OA, which enables its use in research and in the clinic to determine the effect on interventions on improving grip.

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Conflict of Interest Jorge Hugo Villafañe declares that he has no conflict of interest.

Kristin Valdes declares that he has no conflict of interest.

Statement of Informed Consent Informed consent was obtained from all participants and all procedures were conducted according to the Declaration of Helsinki.

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