

# Reliability of Pinch Strength Testing in Elderly Subjects with Unilateral Thumb Carpometacarpal Osteoarthritis

JORGE H. VILLAFANE, PhD, MSc, PT<sup>1</sup>\*, KRISTIN VALDES, OTD, OT, CHT<sup>2</sup>)

<sup>1</sup>) IRCCS Don Gnocchi Foundation: Milan, Italy

<sup>2</sup>) Rocky Mountain University of Health Professions, USA

**Abstract.** [Purpose] The aim of this study was to examine the test-retest reliability of pinch strength testing in elderly subjects with thumb CMC OA. [Subjects and Methods] A total of 27 patients with unilateral right-thumb CMC OA (mean  $\pm$  SD age: 81.3  $\pm$  4.7 years) were recruited. Each patient performed three pain-free maximal isometric contractions on each hand on two occasions, one week apart. Three different measurements were taken: tip, tripod, and key pinch strength. Intraclass correlation coefficient (ICC), standard error of measurement (SEM), and 95% limits of agreement (LOA) calculations were performed. [Results] Test-retest reliability of measurements of tip, tripod, and key pinch strength was excellent for the affected side (ICC=0.93, 0.96, and 0.99) and the contralateral thumb (ICC=0.91, 0.92, and 0.94). [Conclusions] The present results indicate that maximum pinch strength can be measured reliably using the Pinch Gauge 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 pinch strength.

**Key words:** Test-retest, Reliability, Pinch strength

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## 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<sup>1,2</sup>. Individuals with CMC joint OA have decreased pinch strength that impacts hand function and their ability to perform resistive pinch tasks such as clipping nails, turning keys, or opening food packages<sup>3</sup>. CMC OA frequently induces pain at the base of the thumb and narrows the first web space, which in turn causes an alteration of the biomechanics of normal pinch and limitation in hand function<sup>4,5</sup>.

Grip and pinch strength have been widely used in clinical practice as an objective index for measuring functionality of the upper limbs<sup>6</sup>. It is very important to measure grip and pinch strength accurately because the measurement can serve as an indicator of the progress of treatment and rehabilitation of the damaged hand<sup>7</sup>. 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<sup>8</sup>. The experience of the examiner also might influence the measurement accuracy. However, studies that examine the impact of pain and disease on pinch strength

for patients with hand degenerative conditions are scarce. There are several studies that have examined the reliability of the pinch strength test in subjects with hand injuries<sup>9,10</sup> and in subjects without hand impairments<sup>11–13</sup>. Several studies have evaluated the effect of therapeutic interventions on joint function in patients with CMC OA<sup>14–17</sup>. Villafane et al. found high intra-rater reliability when assessing pinch strength in the noninvolved hand using a Mechanical Pinch Gauge<sup>15–18</sup>. Although the reliability of hand grip strength testing of patients with CMC OA has been reported previously, no previous study, to our knowledge, has investigated the reliability of pinch strength testing procedures in thumb CMC OA patients.

Reliable measurement of pinch strength is essential for satisfactory data collection for consistent interpretation of the results and assessing progress made over time. In particular, test-retest reliability is clinically important for correct interpretation of follow-up results. If a measure or tool has good test-retest reliability, it enables accurate comparisons to be made over a period of time. Reliable test results allow clinicians 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 pinch strength test in elderly subjects with unilateral thumb CMC OA.

## SUBJECTS AND METHODS

A convenience sample of 27 elderly subjects (81.3  $\pm$  4.7 years) aged from 70 to 90 years old was recruited for the study from August 2013 to November 2013. Subjects were

\*Corresponding author. Jorge Hugo Villafane (E-mail: mail@villafane.it)

both male (3) and female (24) and had the medical diagnosis of unilateral thumb CMC OA. The subjects were evaluated at the Department of Physical Therapy, Residenza Sanitaria Assistenziale "A. Maritano," Sangano, Italy. All subjects were right-hand dominant. To reach the sample size, the sample calculation was performed based on a priori power calculations for other studies of tip pinch in CMC OA patients to detect differences in reliability of 0.96<sup>13)</sup> and 0.721<sup>4)</sup> at 80% power and a 5% level of significance for tip pinch. Informed consent was obtained from all participants, and all procedures were conducted according to the Declaration of Helsinki. Patients underwent subjective and physical examinations conducted by a therapist with 12 years of experience in treating musculoskeletal disorders. Participants were included if they reported a history of repetitive use of their dominant hand (i.e., ex-factory worker) and exhibited a stage III–IV thumb CMC OA in the dominant hand confirmed radiographically according to the Eaton-Littler-Burton classification<sup>19, 20)</sup>. The combination of radiological and clinical findings has been recommended for making a more accurate diagnosis of thumb CMC OA<sup>21)</sup>. Exclusion criteria were 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 in which pain perception can be altered; presence of any symptom in the nondominant hand; and evidence of radiographic alterations at the first CMC joint in the nondominant hand<sup>20, 21)</sup>.

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 pinch gauge before measurement recording. A portable Mechanical Pinch Gauge (Baseline, Irvington, NY, USA) was used for the pinch strength measurement. The test was performed in the sitting position with the shoulder of the tested arm adducted to the side, the elbow flexed at 90°, and the forearm and wrist set in neutral positions<sup>22)</sup>. Three different measurements were taken in random order: tip pinch between the index finger and thumb, tripod pinch between the index and medial fingers and the thumb, and key pinch (lateral pinch) involving the thumb pulp and the lateral side of the second phalanx of the index finger. The testing protocol consisted of three pain-free maximal isometric contractions for 3 s, for both hands, with a 1-minute pause between measurements. Each patient performed three-pain-free maximal isometric contractions during pinch with each hand on two occasions, one week apart. The mean of these 3 trials was used for analysis. The trial was designed according to the CONSORT publishing guidelines<sup>23)</sup>.

Data were analyzed using SPSS version 19.0 (IBM Corp., Armonk, NY, 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<sub>1,3</sub>). ICC values equal to or greater than 0.80 are considered high. We calculated the 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  $LOA = \text{inter-trial mean difference} \pm 1.96 SD$  of the between trial difference. The SEM expresses the measurement error in the same units as the original measurement, and it is not influenced by variability among patients. The inter-trial agreement was also examined graphically by plotting the difference between test and retest against their means, according to the Bland and Altman approach<sup>24)</sup>. The statistical analysis was conducted at a 95% confidence level, and  $p < 0.05$  was considered statistically significant. ANOVA analysis was performed to determine differences between test and retest pinch strength values.

## RESULTS

The ANOVA results indicated nonsignificant differences between test and retest pinch strength values. The relative reliability between the test and retest was very high. The ICCs for test-retest reliability of measurements of tip, tripod and key pinch strength were 0.93, 0.96, and 0.99 for the affected right hand and 0.91, 0.92 and 0.94 for the contralateral side, respectively. The absolute reliability (SEM and LOA) was good. For tip, tripod and key pinch strength, the mean absolute differences between the test and retest were 0.06 kg, 0.04 kg and 0.01 kg for the affected side and, respectively, and 0.05 kg, 0.06 kg, and 0.03 kg for the unaffected side, respectively (Table 1).

## DISCUSSION

In our study, a high ICC was found for the reliability of pinch strength measurements for both the affected and contralateral hands in subjects with CMC OA. However, there were no significant differences, in both absolute and relative pinch strength, between affected and unaffected hands.

We found lower pinch strength values ranging between 2.44 to 3.11 kg for the affected right hand and 1.94 to 2.88 kg for the left hand compared with the results of 5.6 kg for the right hand and 5.4 kg for the left hand found by Dominick et al.<sup>3)</sup>. Our study sample's mean age of 81.3 years is older than the mean age of 69 years in the study of Dominick et al.<sup>3)</sup>, which may account for our lower pinch strength scores. We found no significant differences in pinch strength between the CMC OA-affected hand compared with the non-affected hand, which supports the conclusion of the study of Dominick et al.<sup>3)</sup>, which found that only OA in the MCP joint of the hand was associated with decreased pinch strength.

There are some limitations to this study. First, the sample size was small. Second, this study sample included individuals with a mean age of 81.3 and stage III–IV thumb CMC OA, and thus the results may not be generalizable to the entire population of patients with CMC OA. Additional studies are needed to examine these relationships among other age groups and other stages of CMC OA. A

**Table 1.** Test and retest values, and index of relative, and absolute reliability of pinch strength in subjects with thumb CMC OA\*

Pinch strength	Side	Test	Retest	Bias	ICC	95% LOA (kg)		SEM
		(kg)	(kg)	(kg)	(95% CI)	Lower	Upper	(kg)
Tip pinch	Affected right hand	2.44 ±1.13	2.49 ±1.21	0.05	0.93 (0.85; 0.97)	-0.80	0.90	0.06
	Contralateral left hand	1.94 ±0.73	1.93 ±0.74	0.01	0.91 (0.81; 0.96)	-0.61	0.62	0.05
Tripod pinch	Affected right hand	3.09 ±1.4	3.07 ±1.46	0.03	0.96 (0.92; 0.98)	-0.76	0.81	0.04
	Contralateral left hand	2.58 ±1.05	2.61 ±1.04	-0.03	0.92 (0.83; 0.96)	-0.85	0.85	0.06
Key pinch	Affected right hand	3.11 ±1.05	3.10 ±1.06	0.02	0.99 (0.97; 0.99)	-0.35	0.38	0.01
	Contralateral left hand	2.88 ±0.62	2.81 ±0.58	0.07	0.94 (0.87; 0.97)	-0.34	0.48	0.03

\* Data are expressed as means ± SD

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

third limitation is that the purpose of this study was to measure the test-retest reliability of the pinch strength test in elderly subjects with unilateral thumb CMC OA; however, this is not a comprehensive measure of hand function. We recommend a patient-centered outcome measure be used in conjunction with pinch and grip assessment. Also, we measured isometric pinch strength. Further studies that quantify the dynamic interaction between the magnitude and directional control of finger forces would greatly improve our understanding of the sensorimotor control of the hand and the clinical evaluation of pinch performance.

The SEMs in this study were small, ranging from 0.01 for key pinch and 0.06 for tripod and tip pinch. Clinically, this implies that a change as small as ± 0.02 to 0.12 kg (2 SEM) is indicative of true change in pinch strength for patients with CMC OA<sup>25</sup>.

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