RELIABILITY STUDY OF MANUAL AND DIGITAL HANDHELD DYNAMOMETERS FOR MEASURING HAND GRIP STRENGTH

Running title: Handheld Dynamometers for Measuring Hand Grip Strength

Dr. Sujit Vasava[1*], Dr. Dinesh Sorani [2*], Dr. Sheshna Rathod [3*]

[1]Assistant professor, Shrimad Rajchandra college of physiotherapy, Uka tarsadia university, Bardoli, India. sujitvasava18396@gmail.com

[2] I/C Principal, Government Physiotherapy College, Rameshwar Nagar, Jamnagar, Gujarat, India. soranidinesh@gmail.com

[3]Tutor/Physiotherapist, Government Physiotherapy College, Rameshwar Nagar, Jamnagar, Gujarat, India. sheshnarathod@yahoo.com

***Corresponding Author**
Dr. Sujit Vasava
Assistant professor
Shrimad Rajchandra college of physiotherapy
Uka tarsadia university, Bardoli
India
Contact no**:** 9638486850
Email:sujitvasava18396@gmail.com

Abstract

Background: Grip strength indicates a patient's progress in rehabilitation, sincerity of effort and ability to return to work. The assessment of grip strength by means of static muscle effort is easy to implement and requires the use of inexpensive and non-invasive instruments.

Objectives: Handheld dynamometers are available in manual and digital version so there is a need to know the reliability of manual hand-held dynamometer and digital hand-held for measuring grip strength.

Method:100 healthy college going students (50 Males and 50 Females) with age group between 18-25 years were randomly selected for the study. The measurement was performed with the Baseline manual dynamometer and Saehan digital dynamometer**.** Inter-rater and Intra-rater reliability was measured for Manual dynamometer and Test-retest reliability was measured for Digital dynamometer.

Results: Intra-class Coefficient for inter-rater by two-way random consistency, intra-rater, and test re-test by two-way mixed agreement. Inter-rater reliability(ICC) was 0.97(95% CI) for both the sides, Intra-rater reliability(ICC) was 0.95(95% CI) for right side and 0.94(95% CI) for left side. and test-retest reliability (ICC) was 0.80(95% CI) for right side and 0.94(95% CI) for left side.

Conclusion: Excellent reliability is found for manual and digital handheld dynamometers.

Key Words: Grip strength, Handheld Dynamometer, Reliability

Introduction

There are four major joints of the hand, carpometacarpal, intercarpal, metacarpophalangeal and interphalangeal joint with9 extrinsic muscles and 10 intrinsic muscles. Each of these muscles is active during gripping activities [1].There are 35 muscles involved in the movement of the forearm and hand, with many of these involved in the gripping activities. During gripping activities, the flexor muscles of hand and forearm work as an agonist and extensors of the forearm muscles work as an antagonist[1].

Reliability defines an instrument's ability to measure consistently and predictably. An instrument that has a high degree of reliability has been statistically proven to measure consistently between sessions, examiners, and instruments. Reliability is expressed in correlation coefficients and standard error of measurement.

In clinical practice, the use of methods and equipment with reliable measures is indispensable since unreliable measures can compromise the evaluation of intervention programs. Therefore, reliability studies in rehabilitation are necessary to ensure that measurement errors are reduced and that changes occurring in the variable of interested are detected by the evaluation tool[2].

Reliability is defined as the extent to which measurements can be replicated. In other words, it reflects not only degree of correlation but also agreement between measurements. There are three types of reliability i.e. Inter-rater reliability, Intra-rater reliability and Test re-test reliability. Interrater Reliability reflects the variation between 2 or more raters who measure the same group of subjects. Intra-rater reliability reflects the variation of data measured by 1 rater across 2 or more trials and Test-retest reliability reflects the variation in measurements taken by an instrument on the same subject under the same conditions. Test re-test reliability generally indicative of reliability in situations when raters are not involved or rater effect is neglectable, such as self-report survey instrument[3].

Grip strength indicates a patient's progress in rehabilitation, sincerity of effort and ability to return to work and the most used measure of grip strength is the effort exerted by the hand using maximum isometric muscle contraction. The assessment of grip strength by means of static muscle effort is easy to implement and requires the use of inexpensive and non-invasive instruments[2].

Grip strength is traditionally measured with a manual hydraulic dynamometer. The instrument is portable, relatively cheap and can easily be used in various work sites and patient locations, including hospital wards. Hand therapists, surgeons and occupational physicians may use different models of dynamometers for measuring the same patient's grip strength. This practice demands that the readings of the different hand dynamometers are comparable. While some instruments have been shown to be comparable, it is not known whether all such instruments provide equivalent grip strength readings. Therefore, the reliability of the grip strength instrument used is crucial[4].

There are three main categories of hand grip dynamometers. These include spring-loaded compression, air compression and hydraulic compression devices. The alternative hand-strength measurement tools, such as the sphygmomanometers, the vigor meter, and computerized dynamometers. The Baltimore Therapeutic Equipment (BTE) and the Dexter are examples of stationary instruments, whereas the Jamar digital dynamometer model 2A19 and the Jamar dynamometer model PC5030PT20 are examples of portable dynamometers[5]. According to Waldo, "since grip is a force, not a pressure, it should be measured in pounds or kilograms. A hydraulic dynamometer is the most accurate choice[6].

There are a range of dynamometers available to objectively measure palmer grip strength. In these instruments, the thenar and hypothenar eminences are supported in the posterior aspect of the handle, inhibiting the action of the thumb, while the other fingers involve the anterior aspect of the handle[2].

The Baseline hand dynamometer gives accurate grip strength readings. The five-position adjustable handle can accommodate any hand size. The maximum reading remains until the unit is reset. The strength reading can be viewed as pound or kilogram. To the best of our knowledge, no studies have been done to assess the inter-rater and intra-rater reliability of Baseline and test-retest reliability of Saehan dynamometer. So, there is the need of the study to find out reliability of both the handheld dynamometers.

Methodology

Participants: One hundred men and women between the age group of 18-24 years were drawn from a healthy participant sample of convenience in our college campus for this study, which was carried out in January 2019. A screening questionnaire determined that they had no history of disease, nor any orthopedic or neuromuscular injuries affecting the hand, arm, or neck within the previous year. All subjects were volunteers who gave written informed consent. The study was approved by the Institutional Ethics Committee (Ref. No. IEC/Certi/27/01/2019). The healthy participants were composed of 50 males and 50 females.

Instrumentation: The digital handheld dynamometers had a range of measure from 5.0 kg to 100.0 kg, whereas the manual handheld dynamometers had a range of measure from 0.0 kg to 100.0 kg.

Procedure: A comprehensive verbal description of the nature and purpose of the study was given to the participants. The research team demonstrated competency in administering the grip test and recording the data accurately. Once accepted as eligible to participate, the subject removed all hand jewellery and washed and dried his/her hands prior to being tested. All subjects were tested on two devices, Manual handheld dynamometer (BASELINE®; 12-0241) and Digital handheld dynamometer (Saehan – DHD 1; SH1001) The same calibrated instrument was used for all the data collection and the procedure was as follows.

The subjects were seated comfortably with chairs providing back and arm support. The subjects' shoulders were abducted, with elbows flexed to 90 degrees, and wrists and forearm both in a neutral position. During testing each subject rested his/her contralateral hand on her thigh and was asked to remain in that position during the trials. Subjects were instructed to grip the dynamometer smoothly for approximately 3 seconds at maximal ability. Before testing, subjects were permitted to practice gripping the device once with each hand. Grip scores were recorded in kilograms. The same measurement tool was used throughout the data collection process.

The display of dynamometers faced the examiner, providing blind measurements to the participant. Each participant performed the test thrice with each hand (right and left alternatively), with 1-minute rest between trials. Participants were instructed to squeeze gradually and continuously for at least 3 seconds. The examiner used verbal reinforcement for the duration of those three seconds. Verbal instructions were given like, Are you ready? Squeeze as hard as you can ... Harder ... Harder! ... Relax. II. For each measure, the order of the dynamometer to be used, the hand to be tested first was chosen randomly. For assessing the inter-rater reliability, after measuring the data by the first rater fifteen-minute break was given then second rater was measure the same tool measurement for each subject. For assessing intra-rater reliability, the entire procedure was repeated after 24 hours in the same testing conditions by the same rater. Hence a total of 12 grip strength trials were obtained from each subject.

A second day of grip-strength on the digital dynamometer and manual dynamometer were performed to provide data for test-retest reliability and intra-rater reliability analysis. These two measurement sessions did not occur on the same day, to minimize the confounding variable of muscle fatigue, but they were less than five days apart to minimize the potential for an actual change in grip strength. The times of day for the two testing sessions were within four hours of one another, such that both sessions occurred either in the morning, in the afternoon, or in the evening.

Statistical analysis

An average of 3 readings was taken and all analysis was carried out in SPSS windows Version 20.0. Out of 3 readings, the maximum reading was used for statistical analysis.

Results

Table I: Demographic characteristics of all subjects

Variables	Male (Mean ±SD)	Female (Mean ±SD)	Total (Mean ±SD)
Number of subjects	50	50	100
Age (Years)	19.62 ±1.39	20.28 ±1.84	19.95 ±1.65
Height (Meters)	1.70 ±0.06	1.59 ±0.06	1.65 ±0.08
Weight (Kg)	59.08±12.65	51.78 ±8.76	55.43 ±11.43
BMI (Kg/m^2)	20.47 ±4.69	20.27 ±3.29	20.37 ±4.03

Table 2: Dominancy of all subjects

Side	Male	Female	Total
Right	38	47	85
Left	12	03	15

Inter-rater reliability was analyzed by two-way random consistency and Intra- rater and Test re- test was analyzed by two-way mixed agreement.

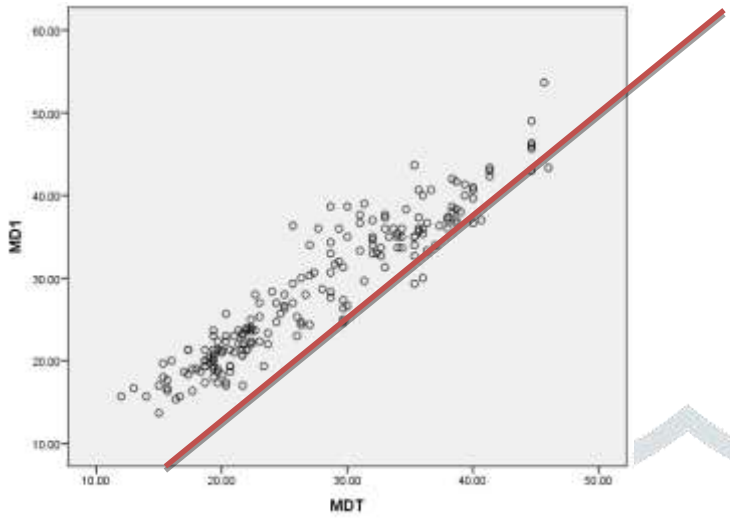
ICC values less than 0.5 are indicative of poor reliability, values between 0.5 and 0.75 indicate moderate reliability, values between 0.75 and 0.9 indicate good reliability, and values greater than 0.90 indicate excellent reliability.

Table 3: Intraclass Correlation Coefficients values of different reliabilities.

Reliability	Side	ICC	95% CI	
			Lower bound	Upper bound
Interrater reliability	Right	0.970	0.955	0.979
	Left	0.971	0.957	0.981
Intra-rater reliability	Right	0.956	0.933	0.971
	Left	0.949	0.922	0.966

Test re-test reliability	Right	0.804	0.709	0.868
	Left	0.945	0.919	0.963

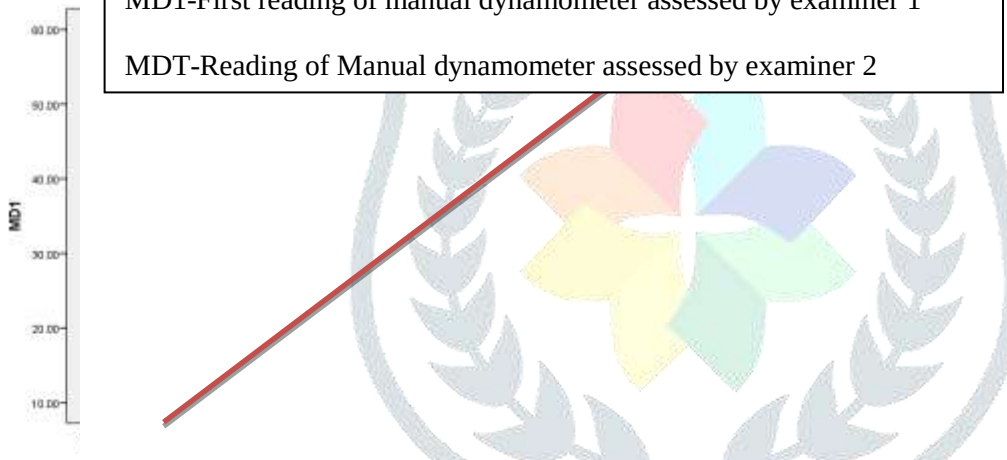
Interpretation: Inter rater and Intra rater reliability for both the side is excellent and test-retest reliability for left side is excellent and right side is good.



Graph 1: Scatter diagram of inter-rater reliability

MD1-First reading of manual dynamometer assessed by examiner 1

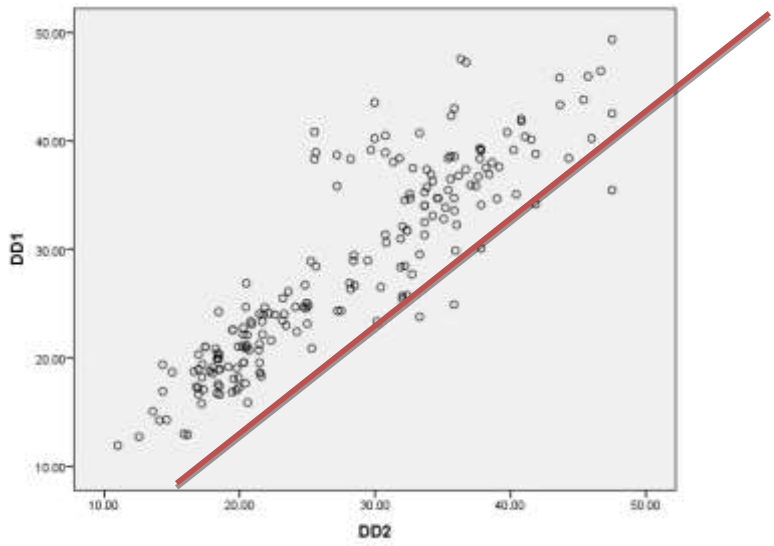
MDT-Reading of Manual dynamometer assessed by examiner 2



Graph 2: Scatter diagram of intra-rater reliability

MD1- First reading of manual dynamometer assessed by examiner 1

MD2-Second reading of manual dynamometer assessed by examiner 1



Graph 3: Scatter diagram of test re-test reliability

DD1-First reading of digital dynamometer assessed by examiner 1

DD2-Second reading of digital dynamometer assessed by examiner 1

Discussion

The most sophisticated testing instruments, standardized tests, have common elements that include: (1) reliability, (2) validity, (3) administrative instructions, (4) equipment criteria, (5) norms, (6) instructions for interpretation, and often, (7) a bibliography. Reliability and validity are the most critical factors, for without these, the remaining criteria are rendered meaningless[7].

Given the current need to ensure that evaluation tools used in clinical practice are reliable, it is essential to prove the reliability of the assessment tools. Our study aimed to find out reliability of BASELINE manual and Saehan digital handheld dynamometers.

As the result suggest that there was excellent intra-rater reliability for right side where the lower bound was 0.933 and upper bound was 0.971 (ICC = 0.956 with 95% CI) and for Left side there was also excellent reliability where the lower bound was 0.922 and upper bound was 0.966 (ICC=0.949 with 95% CI) of grip strength using manual handheld dynamometer in college going students.

Inter-rater reliability for right side was excellent where the lower bound was 0.955 and upper bound was 0.979 (ICC = 0.970 with 95% CI) and for Left side there was also excellent reliability where the lower bound was 0.957 and upper bound was 0.981 (ICC=0.971 with 95% CI)of grip strength using manual handheld dynamometer in college going students

There was "moderate to good" test-retest reliability for right side where lower bound was 0.709 and upper bound was 0.868(ICC = 0.804 with 95% CI) and there was excellent test re-test reliability for left side where lower bound was 0.919 and upper bound was 0.963(ICC= 0.945 with 95% CI) of grip strength using digital handheld dynamometer in college going students.

Our findings were consistent with findings of Mathiowetz etal.[8]and Reis et al[9].According to Virgil Mathiowetz et al the Jamar and Baseline hydraulic dynamometers have acceptable inter-instrumental reliability and concurrent validity (i.e., they measure grip strength equivalently) and can be used interchangeably[8].

According to Reis et al the Saehan dynamometer is valid, reliable, and comparable to the Jamar dynamometer. Therefore, the Jamar and Saehan dynamometers measure handgrip strength equivalently[9]. Handgrip strength is part of several health-related fitness tests and it has been widely used in experimental and epidemiologic studies. Therefore, from a public health perspective, it is important to standardize the Reliability of the dynamometers for the assessment of the patient.

Limitation and Future Implication

The data was collected only from the young adult population. The results cannot be generalized for children and the elderly, as these age groups were not included in the study and the evaluations were performed with the handles of both dynamometers regulated in the 2nd position. Future studies should determine if tests performed with the first, third, fourth and

fifth positions of the Saehan dynamometer handle are reliable when compared with tests performed with the same positions of the Baseline dynamometer.

Conclusion

The hydraulic Baseline and Saehan dynamometers are highly reliable when adjusted in the second position, when standardized instructions and positioning are adopted for the manual grip force tests.

References

1. Hall S. *Basic Biomechanics*. Pp 217-219. New York. NY 2007
2. Amaral JF, Mancini M, Novo Júnior JM. Comparison of three hand dynamometers in relation to the accuracy and precision of the measurements. Brazilian Journal of Physical Therapy. 2012 Jun; 16(3):216-24.
3. Koo TK, Li MY. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. Journal of chiropractic medicine. 2016 Jun 1; 15(2):155-63.
4. Svens B, Lee H. Intra-and inter-instrument reliability of Grip-Strength Measurements: Grip Track™ and Jamar® hand dynamometers. The British Journal of Hand Therapy. 2005 Jun; 10(2):47-55.
5. Shechtman O, Gestewitz L, Kimble C. Reliability, and validity of the DynEx dynamometer. Journal of Hand Therapy. 2005 Jul 1; 18(3):339-47.
6. Waldo BR. Grip strength testing. Strength & Conditioning Journal. 1996 Oct 1; 18(5):32-5.
7. Fess EE. The need for reliability and validity in hand assessment instruments. Journal of Hand Surgery. 1986 Sep 1; 11(5):621-3.
8. Mathiowetz V, Vizenor L, Melander D. Comparison of baseline instruments to the Jamar dynamometer and the B&L engineering pinch gauge. The Occupational Therapy Journal of Research. 2000 Jul; 20(3):147-62.
9. Reis MM, Arantes PM. Assessment of hand grip strength-validity and reliability of the saehan dynamometer. Fisioterapia e Pesquisa. 2011 Jun; 18(2):176-81.