Validity and reliability of Squegg device in measuring isometric handgrip strength

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Abstract. – OBJECTIVE: The quantitative measurement of handgrip strength is important in assessing and charting the progress of patients with neuromuscular diseases. The aim of this research was to determine the intra-rater and inter-rater reliability and the validity of the Squegg digital dynamometer.

SUBJECTS AND METHODS: Twenty-one females and nine male participants with an age range between 18 and 40 years volunteered for the study. Three testers each took three measurements with a Squegg device and a Jamar dynamometer using standardized measurement techniques. Intra- and inter-tester reliability were calculated using the intra-class correlation coefficient (ICC). To investigate the relationship between hand measures and isometric handgrip strength, the Pearson correlation coefficient test was used. To determine the agreement between the two devices, a Bland Altman plot was constructed, and the concurrent validity of Squegg was calculated.

RESULTS: The intra-rater reliability coefficients for both Jamar and Squegg were greater than 0.99 for all three testers, indicating excellent intra-rater reliability. The inter-rater reliability of Jamar (ICC=0.93) and Squegg (ICC=0.87) was excellent. With an ICC of 0.844 and an r-value of 0.720, Squegg with Jamar demonstrates good validity and statistical significance (*p*=0.001).

CONCLUSIONS: The isometric handgrip strength and hand measures showed a moderate correlation in the study population. The Squegg isometric handgrip dynamometer has good concurrent validity and great intra- and inter-rater reliability in healthy individuals. The validity of Squegg in patients with neuromuscular diseases that affect hand function has to be investigated further.

Key Words:
Validity, Reliability, Squegg, Isometric handgrip strength, Jamar.

Introduction

Therapists and physicians assess handgrip strength in a variety of clinical settings, including hand therapy and occupational rehabilitation, as well as a basic procedure following surgical techniques[1]. A quantifiable hand grip measurement is critical for setting realistic treatment and outcome goals. Handgrip measurement is used in sports science and medicine areas as a functional test of overall strength, musculoskeletal function, weakness, and disability[2]. Handgrip strength measured with a handheld dynamometer produces an isometric force measure that can identify upper extremity muscle weakness and indicate overall strength[2]. The availability of a non-invasive and inexpensive manual dynamometer, as well as the

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high reliability of its measurement, has resulted in increased utility and feasibility with the widespread use of isometric handgrip (IHG) strength test results[3]. The results of grip strength tests have also been used to establish performance benchmarks. Age, gender, anthropometric factors, hand dominance, and various health conditions influence it, particularly in the elderly[2-5].

Over the last decade, many devices for measuring handgrips have been documented in the literature. The Jamar hand dynamometer introduced in 1954 has been reported in recent studies[5,6] as the most reliable and accurate device for the measurement of handgrip strength. It registers handgrip force in pounds per square inch (PSI) by using adjustable hand spacing inside a sealed hydraulic system[6]. The Jamar dynamometer was traditionally used to assess the handgrip strength in both clinical and epidemiological settings[7]. This dynamometer has been used as a gold standard in several studies[7] to assess the criterion-related validity of other dynamometers. Myogrip, Martin Vigorimeter, and Bulb dynamometers[8,9] are other devices used to measure the handgrip strength in clinical settings.

It is highly difficult to get significant grip strength measurements in patients with hand abnormalities or high tissue sensitivity using standard and commercially accessible devices because they may not be able to create adequate force required[10]. The Squegg device is a modern device developed with improved ergonomic benefits used to measure the IHG strength[11]. Roshy Rajan and Saket Gunjan introduced the Squegg device in 2017, and it was manufactured in 2019[11-13]. The manufacturer claims the main aim of this device is to help in grip training, as studies[11-13] have proven that grip training improves cognitive functions and lowers the risk of heart attacks. It was designed as a portable and pocket-friendly device that can be carried around with a battery-long shelf life. It connects to the smartphone *via* Bluetooth, allowing the person to evaluate the grip strength, keep track of the grip count, and view the progress. Furthermore, it claims to keep the person engaged in grip training through challenging games[14].

Lower handgrip strength has been linked to arterial stiffness, elevated systolic blood pressure, and cardiovascular disease[15]. In previous investigations[16], IHG training devices were proven to be efficient in lowering blood pressure in hypertensive patients on medication. The new digital dynamometer device (Squegg), like the other IHG training devices, can be used to evaluate and train IHG strength in patients with neuromuscular problems and mild to moderate hypertension. Despite the fact that Squegg is available in the market, its reliability and validity are unknown. The reliability and accuracy of the instrument in measurement-related issues are of great importance when measuring the grip strength. The isometric handgrip strength is influenced by the hand measurements and anthropometric measurements[17]. The study's objectives were to compare the Squegg device's reliability and concurrent validity to the traditional Jamar dynamometer in measuring isometric handgrip strength, to investigate the relationship between hand measurements, anthropometric measurements, and resting blood pressure and handgrip strength measured by Squegg and Jamar dynamometers.

Subjects and Methods

A cross-sectional study was conducted assessing isometric handgrip strength with the Squegg device (Plantation, FL, USA) and Jamar dynamometer (JLW Instruments, Chicago, IL, USA) thrice by three testers. The safety of the experiments was ensured by taking all required precautions. Each of the researchers conducting the test underwent pre-training to ensure a standard procedure was maintained for measuring the heart rate, blood pressure, height and weight, and participant positioning during the test. The instructions for the participants while performing the test, handling of the devices, hand measurements, and recording of the readings were included in the pre-training. Partial counterbalancing was used for testing the validity and reliability of the devices on different participants, and sufficient time was given between the measurements to reduce the carryover effect during the study.

The participants in this validity study were 21 females and 9 males who were recruited using verbal and social media advertisements. Before using both devices for handgrip strength measurements, the researchers measured the heart rate and blood pressure response. Participants had to be between the ages of 18 and 40 years and had normal blood pressure. Participants having a known history of hypertension, those on any type of medication, smokers, and those with a history of cardiac arrhythmia, coronary arterial disease, congestive heart disease, stroke, or acute myocardial infarction were all excluded. Table I shows the participant characteristics.

Each participant completed a signed consent form. Following that, their height and weight were recorded prior to the study using a height and weight scale. For the purposes of the analysis, we calculated the mean of the two measurements of systolic blood pressure and diastolic blood pressure (BP). The BP was measured in a seated position with a mercury sphygmomanometer after at least 5 minutes of rest and no vigorous exercise in the preceding 30 minutes. A Jamar dynamometer that records force in units of kg was used. The dynamometer was set at the third handle space. The Squegg digital dynamometer also measured IHG strength in units of kg.

IHG was determined using the Jamar dynamometer and the Squegg unit; each tester performed three trials with each device. After a 30-minute break, the Squegg unit was used. Prior to conducting the study, it was ensured that the participants understood the directions completely. Each of the three trials with each tester began with the verbal command "begin squeezing" and ended with the command "relax". The reading was recorded in kilograms. Following a two-minute rest period (an effective amount of time for fatigue elimination), the second and third trials were repeated. The tester manually recorded each trial reading. The highest value for IHG strength was determined in each of the three trials using a Jamar dynamometer and a Squegg digital dynamometer.

The individuals were asked to sit comfortably in a chair with their feet flat on the floor and their backs supported. The dominant arm was positioned at the end of the chair arm at 90° elbow flexion. Inhaling through their noses and exhaling through pursed lips while flexing and squeezing their fingers was instructed to participants. While using the Squegg device to assess handgrip strength, the participants were given the same instructions. After 30 minutes of rest, the participants were instructed to repeat the procedure with the next device. Each participant was required to wait 30 minutes in a temperature-controlled room before moving to a new room for the remaining two tests. The order of performing the tests was determined randomly, and the testers were blinded. The experimental procedure followed by each tester while measuring the IHG is illustrated in Figure 1.

The investigators measured the subjects' dominant hands' length, width, and circumference in inches with a measuring tape. The dominant arm was flexed to 90 degrees and rested on the chair's fixed armrest, with the wrist neutral. Hand length was measured from the distal third phalange of the third metacarpal to the crease under the palm. The palm's widest part was measured with a measuring tape. The dominant hand's circumference was measured by wrapping the measuring tape around the palm, excluding the thumb (Figure 2).

Statistical Analysis

SPSS 27 (IBM Corp., Armonk, NY, USA) was used to conduct the statistical analyses. The mean and highest of three values were presented for dynamometry measurements. The intra-class correlation coefficient (ICC) was used to calculate intra-tester and inter-tester reliability. The IHG strength was correlated with body mass index (BMI), waist circumference (WC), BP, Hand length, and width using the Pearson correlation coefficient test or Spearman Rho correlation coefficient test. Using a Bland-Altman plot, we compared the difference (bias) between the two dynamometers to the average of all dynamometers

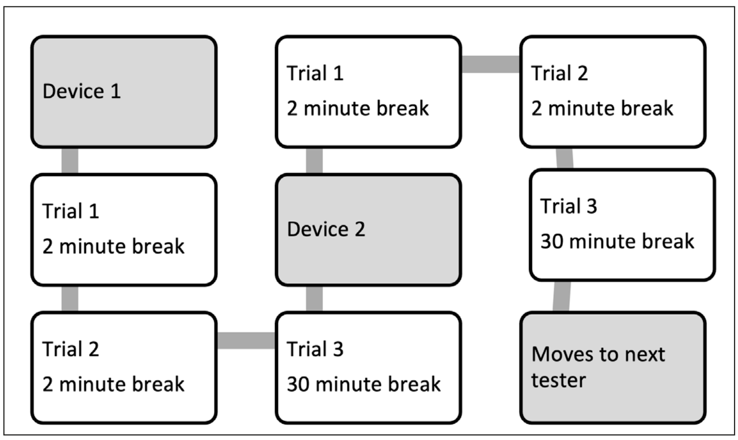

Figure 1. Procedure followed by each tester.

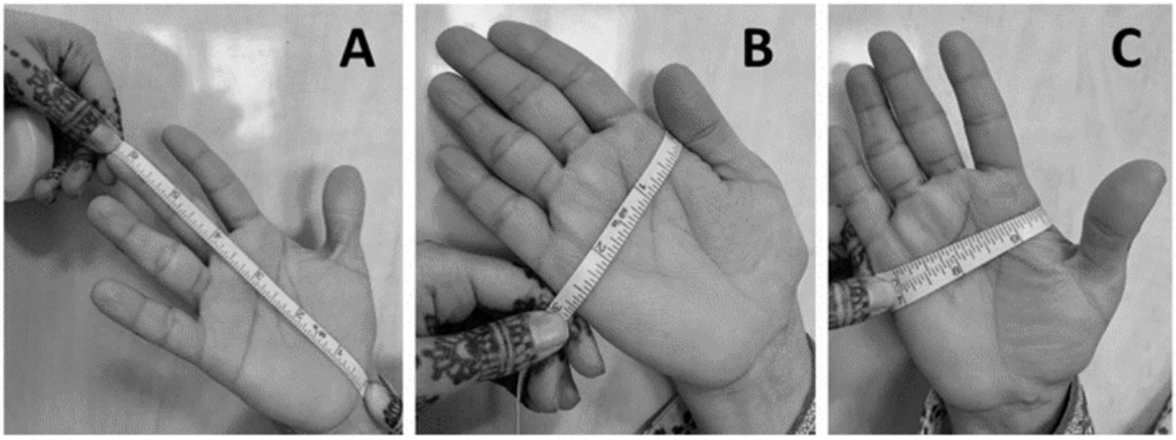

Figure 2. Measurement of (**A**) hand length, (**B**) hand width, and (**C**) hand circumference.

for all participants. The level of statistical significance was set at $p \leq 0.05$.

Results

Table I summarizes the characteristics of the participants. The study involved 21 females and 9 males with a range of age (28.43±9.87) and body mass index (BMI) (24.35±3.66).

The intra-rater reliability of Jamar and Squegg is presented in Table II. The intra-rater reliability coefficients for both devices were greater than 0.99 for all three testers, indicating excellent intra-rater reliability. Table III compares the reliability of the Squegg and Jamar dynamometers throughout all three sessions using the mean and standard deviation data. Jamar and Squegg exhibit intra-class correlation coefficients (ICC) of 0.93 and 0.87, respectively, which are statistically

Table I. Physical characteristics of the participants.

Variables	*Mean (SD)*
Age (years)	28.43 (9.87)
Gender (female: male)	21:9
Body mass index	24.35 (3.66)
Waist Circumference (inches)	32.92 (4.43)
Hand length (cms)	7.16 (0.67)
Hand width (cms)	3.28 (0.39)
Hand circumference (cms)	7.50 (7.00, 8.00)
Systolic blood pressure (mmHg)	125.83 (11.26)
Diastolic blood pressure (mmHg)	75.63 (8.12)

SD: standard deviation; cms: centimeters; mmHg: millimeters of mercury.

Table II. Intra rater reliability of Jamar and Squegg devices.

Rater	*ICC (95% CI)*	*p-value*
Rater 1 Jamar device	0.997 (0.995, 0.998)	<0.001
Rater 2 Jamar device	0.993 (0.988, 0.997)	<0.001
Rater 3 Jamar device	0.993 (0.987, 0.996)	<0.001
Rater 1 Squegg device	0.995 (0.991, 0.997)	<0.001
Rater 2 Squegg device	0.994 (0.990, 0.997)	<0.001
Rater 3 Squegg device	0.995 (0.991, 0.998)	<0.001

SD: standard deviation; cms: centimeters; mmHg: millimeters of mercury.

Table III. Inter tester reliability among three testers for Jamar and Squegg devices.

	Tester 1 mean (SD)	Tester 2	Tester 3	Average	ICC (lower, upper bound)	*p*-value
Jamar	27.73 (10.41)	27.18 (9.84)	27.27 (11.18)	27.39 (10.24)	0.93 (0.87, 0.96)	<0.001
Squegg	30.07 (7.76)	30.83 (8.05)	31.10 (7.05)	30.67 (7.28)	0.87 (0.77, 0.93)	<0.001

SD: standard deviation; ICC: intraclass correlation coefficient.

Table IV. Correlation of IHG (Squegg) strength with the hand measurements, cardiovascular risk factors, and physical activity.

	r	p
Body mass index	-0.053	0.782
Waist Circumference	0.179	0.344
Hand length	0.561	0.001
Hand width	0.532	0.002
Hand circumference	0.612 (spearman)	<0.001
Systolic blood pressure	0.323	0.081
Diastolic blood pressure	0.123	0.519

IHG: isometric handgrip; r: correlation coefficient.

Table V. Correlation of IHG (Jamar) strength with the hand measurements and cardiovascular risk factors.

	r	p
Body mass index	-0.036	0.848
Waist Circumference	0.248	0.187
Hand length	0.630	<0.001
Hand width	0.663	<0.001
Hand circumference	0.487 (spearman)	0.006
Systolic blood pressure	0.310	0.095
Diastolic blood pressure	0.053	0.781

IHG: isometric handgrip; r: correlation coefficient.

significant (p=0.001) and fall within acceptable inter-rater reliability levels, as shown in Table III.

The r-value for Squegg dynamometer indicates a moderate correlation but statistically significant association with hand length and width (p=0.001). In the case of Squegg measurements, the only statistically significant association is for hand circumference, with r=0.612 and p=0.001, as demonstrated in Table IV. Our findings show no association between blood pressure and IHG readings in the cohort we analyzed. The r-value for Jamar dynamometer indicates a moderate but statistically significant association with hand length and width (p<0.001) with no association between blood pressure and IHG readings (Table V).

Squegg with Jamar has an ICC of 0.844 and an r-value of 0.72, showing that it is both valid and statistically significant (p=0.001). Thus, when compared to the well-established Jamar dynamometer, the digital handheld Squegg dynamometer is valid and reliable for determining the strength of the handgrip (Table VI).

The Bland Altman plot was used to plot the difference in scores for two measurements *vs.* the mean for each individual. The width of the 95% confidence intervals (mean difference) and the mean difference between the two measurements were determined to be -7.04 and 12.84, respectively, and the majority of scores fall within the 95% confidence interval, indicating a normal distribution of the differences and valid agreement between the two tests.

Discussion

The impact of mental health issues on the use of this device in populations with neurological illnesses has to be investigated further. The Jamar dynamometer is the "gold standard" for measuring grip strength among the several instruments available[18]. However, it should be noted that there are differences between the dynamometers, such as handle shape, data display, and weight, which can result in statistically different results between the two devices[19]. To avoid this, we used the same dynamometers for testing and retesting.

Trampisch et al[5] found that assessing grip strength with the Jamar Plus dynamometer is easier and faster if a single standard handle position is used rather than numerous varied positions to

Table VI. Concurrent validity of Squegg with Jamar.

Concurrent validity	
ICC=0.844 (0.699, 0.923)	$p \leq 0.001$, r=0.72, $p \leq 0.001$

ICC: intraclass correlation coefficient; *p*-value: probability; r: correlation coefficient.

reduce fatigue and increase subject comparability[5]. As a result, in the current investigation, a single handle position was used to improve the accuracy of the Jamar dynamometer results. The best hand posture for using the Squegg apparatus to test isometric handgrip strength is unknown. According to the findings of our study, the measures were consistent with both devices, indicating high reliability. Hand length and width were found to have a statistically significant association with the readings acquired by the Jamar dynamometer in the correlation analysis. This suggests that hand length can influence the readings produced by the Jamar dynamometer. In the case of the Squegg digital dynamometer, hand circumference was statistically significant. Petrofsky et al[20] observed that handgrip size and hand dimensions influenced isometric handgrip strength significantly. Our findings are in line with previous research[20]. While the sample size (n=30) was adequate, a larger sample size will be necessary to adequately represent the target population, investigate confounding variables such as hand dominance and gender, and conduct a more detailed analysis.

The association between BMI and IHG strength is not statistically significant. However, we cannot make any inferences due to the study's small sample size. There were only two patients with a BMI greater than 2 kg/m^2. A larger sample size with a range of BMI values is required to generalize the statement. Nevertheless, our findings are consistent with a population-based study undertaken to produce normative data in the Australian population, which had a mean BMI of 28.1 kg/m^2[21].

Despite the high accuracy (3%) with which the Jamar dynamometers measure grip strength, the markings are differentiated by five points for lb. or kg[22,23]. Because the tester is intended to estimate the readings on the Jamar dynamometer dial display when the needle pauses outside of the 5 kg interval readings, measurement discrepancies may have an impact on the study's conclusions. The data is displayed on the screen of digital dynamometers, allowing for a digital read-out. This improves precision by displaying values closer to 0.1 lb or kg than the Jamar dynamometer's 5 lb or kg. This improves inter-rater reliability and reduces the possibility of measurement errors. Additionally, the digital Dynamometer's improved sensitivity to applied force is an advantage. Low grip strength readings that were too small to be recorded by the dynamometer may not be registered. However, many digital dynamometers, such as the Squegg, are new to the market and lack empirical proof demonstrating their reliability and validity[24-25]. Squegg may be recommended for use by physiotherapists following the establishment of its reliability and validity in this study. The game choices included in this wireless device may appeal to children and younger age groups, as handgrip strengthening activities will be regarded as enjoyable rather than burdensome, hence improving their interest in and adherence to exercise[21-23].

Conclusions

The results of this study demonstrated the reliability and concurrent validity of Squegg in the normal population. The isometric handgrip strength measures taken by Jamar and the digital instrument demonstrated a significant correlation with hand measurements. In contrast, handgrip strength was not associated with anthropometric parameters or resting blood pressure in young asymptomatic individuals.

Conflict of Interest
The authors declare that they have no conflict of interests.

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Ethics Approval
The study was approved by the localized Ethics Committee at Prince Sattam bin Abdulaziz University (ethical approval number RHPT/22/034).

Informed Consent
Every participant was informed about the research purpose and signed a consent form.

Data Availability
The authors declare that all relevant data supporting the findings of this study are available within the article.

Authors' Contributions

KCB, AK, SB, HM, FM, FR, GKA, MT, RSR, JST, WKA, WE, RSH, and SHE were involved in the planning design of the study. KCB, AK, SB, HM, FM, WKA, WE, RSH, SHE, and FR, were involved in the literature search, and KCB, AK, SB, HM, and GKA analyzed the data. KCB, RSR, WKA, and WE developed the manuscript, and all authors agreed to its final submission. All authors guarantee the integrity of the content and the study. All authors read and accepted the final manuscript.

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