Research Article

Interinstrument Reliability Between the Squegg® Smart Dynamometer and Hand Grip Trainer and the Jamar® Hydraulic Hand Dynamometer: A Pilot Study

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Importance: Occupational therapists need dependable and accurate instruments for remote assessments and monitoring of hand functionality. These assessments monitor progress, evaluate interventions, and guide independence goals.

Objective: To assess the interinstrument reliability and concurrent validity of the Squegg® Smart Dynamometer and Hand Grip Trainer and the Jamar® Hydraulic Hand Dynamometer.

Design: Repeated-measures design.

Setting: Individual clinic in Bucharest, Romania.

Participants: Forty middle-age and older adult volunteers, healthy and free from any neuromuscular, orthopedic dysfunction that affected hand strength.

Outcomes and Measures: Participants' maximal grip strength (MGS) for both their dominant and nondominant hands was measured with both devices. Participants with odd-numbered IDs were measured with the Squegg first and the Jamar second, and those with even-numbered IDs were measured in opposite sequence.

Results: Paired-samples *t* tests on overall mean MGS and mean MGS (three measures on each hand) showed no statistically significant differences between the two devices. Intraclass correlation analysis showed good to excellent interinstrument agreement. Pearson correlations between measurements across all participants, and hands, indicated strong agreement.

Conclusions and Relevance: The Squegg shows promise for health care professionals, including occupational therapists, for grip strength assessment in clinical contexts.

What This Article Adds: These results offer initial psychometric data for a new remote MGS measurement device. MGS is crucial for assessing the physical function of aging adults. Reliable measurements from such a device are vital for occupational therapists to guide treatment interventions and assess hand function's impact on daily activities.

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Physical functioning describes an individual's capacity to successfully perform physical tasks that are essential to everyday life. This is key to our ability to perform the basic and instrumental activities of daily living. It is increasingly apparent that objective measures of physical functioning, such as grip strength, not only characterize physical capacity but also act as a marker of an individual's current and future health (Cooper et al., 2011). A grip strength test evaluates the static force that a person's hand emits when squeezing around a dynamometer. The output is expressed in kilograms, pounds, or Newtons (Massy-Westropp et al., 2011). This test is a quick, reliable tool for evaluating the physical function and vitality of aging adults (Labott et al., 2019).

There has been considerable interest in the role of grip strength as a marker during the aging process, in its potential as a tool for clinical assessment, and in its use in epidemiological and intervention studies (Dodds et al., 2014). Hooyman et al. (2021) suggests that over 210 longitudinal studies from the Inter-university Consortium for Political and Social Research report grip strength data in their samples. Physical function begins to decline with age, which results in difficulties with performing various daily activities; this, in turn, can lead to the avoidance of these activities (Garber et al., 2010). These gradual and subtle changes can go unobserved by family members, or even health care providers, up to the point where the older adult is unable to perform the activity independently (Garber et al., 2010). Furthermore, one of the most common methods used to depict overall muscle strength is handgrip, as assessed by means of dynamometry, and such assessment can be useful in predicting functional independence outcomes in daily activities (Bohannon et al., 2019). Therefore, the frequent evaluation of grip strength is particularly important in detecting these subtle changes in a timely manner.

Traditionally, the practice of assessing grip strength by health care providers, including occupational therapy practitioners, in the United States is performed in person, which can be time consuming and resource demanding. In response to the coronavirus disease 2019 (COVID-19) pandemic and overall increase in teletherapy, the American Medical Association expanded *CPT*® (*Current Procedural Terminology*) codes. *CPT* codes that are relevant to occupational therapy now include categories such as remote therapeutic monitoring (see AOTA, 2023). Given this, a more relevant option to assess grip strength could be to use a device that enables remote assessment; specifically, the collection of grip strength data that would not implicate travel for either the participant or any health care staff. For this to be a viable option, this device would need to produce reliable and valid results. Additionally, the technology should enable easy measurement, scoring, and interpretation of results.

Several studies (e.g., Allen & Barnett, 2011; Lee et al., 2020; Mathiowetz, 2002; Mutalib et al., 2022) have suggested that the gold-standard tool for assessing grip strength is the Jamar® Hydraulic Hand Dynamometer (J. A. Preston Corporation, Clifton, NJ). It has consistently shown excellent test–retest reliability and interrater reliability, both in clinic and in research (Mathiowetz, 2002). Still, the Jamar dynamometer has several limitations. First, because it is a mechanical measurement tool, it cannot display or record rapid grip and release handgrip force data over time; nor can it measure, display, or record sustained handgrip force at all (Lee et al., 2020). Other limitations relate to its handling and maintenance, it is a relatively heavy device, with marginal robustness, which requires regular recalibration. A device that would allow for sustained handgrip strength values and automatic data recording as well as for improved usability may prove more convenient for both remote and clinical assessment.

The Squegg® Smart Dynamometer and Hand Grip Trainer (hereinafter referred to as the Squegg; The BioSparrow, Plantation, FL) is a digital, handheld, dynamometer that enables Bluetooth connection to a mobile device (e.g., mobile phone, tablet) to visually display and record rapid grip and release handgrip force data over time in a cloud-based system. This Food and Drug Administration class II, 510(k)-exempt medical device is shaped like an egg; has four finger indentations for the second, third, fourth, and fifth digits, and has an outer silicone shell to prevent moisture accumulation. Designed for grip training, the Squegg comes with a companion app that allows for the display and recording of sustained handgrip strength data over time. Although it was not tested in this study, this may have functional implications for the assessment of activities of daily living and instrumental activities of daily living, compared with a rapid grip and release assessment alone. All these features could make the Squegg a potentially useful device for remote, clinical assessment of grip strength by health care providers, including occupational therapy practitioners. However, the first step in determining whether the Squegg could be used in remote assessment is to evaluate whether the device can produce reliable and valid results. To this end, we conducted this pilot study to investigate the interinstrument reliability and concurrent validity between the Squegg and the Jamar dynamometer, which has been described as the gold-standard tool for handgrip strength evaluations (e.g., Allen & Barnett, 2011; Lee et al., 2020; Mathiowetz, 2002; Mutalib et al., 2022).

Method

The study was approved by each institution's ethics committee.

Transparency and Openness

Neither the design nor the hypotheses, nor the analytic plan for this study were preregistered.

The deidentified data and SPSS syntax that support the findings of this study can be accessed at https://osf.io/8k2d9/?view_only=6c573c8f913049688dc8408076b3c41a.

Participants

A sample of 20 female and 20 male volunteers, right- and left-hand dominant, were recruited from the Centrul de Excelență pentru Boli de Memorie și Medicina Longevității clinic in Bucharest, Romania, by means of convenient sampling. All participants were selected by the clinics' geriatricians from their patient pool. The geriatricians only selected people who were healthy and free from any neuromuscular, orthopedic dysfunction that affects hand strength. Patients with injuries, deformities, or degenerative or inflammatory functional limitations of the upper extremities, as well as patients with dementia or a history of brain injury or stroke, were not included in the study. All participants provided written consent before the study. Participants were between ages 55 and 89 yr and were predominantly self-reported right-handed (right-handed, $n = 38$; left-handed, $n = 2$). All participants were Caucasian Europeans (Romanians). Participant demographic data are presented in Table 1.

Instruments

The Jamar hydraulic hand dynamometer and the Squegg were used to measure the maximal grip strength of all participants. The feature comparison between the Jamar and Squegg devices is presented in Table 2.

Design

We used a repeated-measures design to control for individual differences between participants. Participants were given numerical IDs and were assigned to start with either the Squegg or the Jamar device first. We measured the right- and left-hand grip strength of participants with odd-numbered IDs using the Squegg dynamometer first and the Jamar dynamometer second. Participants with even-numbered IDs were measured in the opposite sequence. The present study followed a systematic process previously used for data collection (Mathiowetz et al., 2000).

All instruments were checked for damage and inspected for proper function, and the Jamar device was recalibrated right before the start of the study. The Jamar dynamometer's adjustable handle was set to position 2 (49 mm), as recommended in the literature (e.g., Mathiowetz et al., 2000). In collecting grip strength data, we followed the standard procedures as described by Mathiowetz (2002) and recommended by the American Society of Hand Therapists (Fess, 1992).

Testing was conducted in Romanian (the native language of Andreea Stamate and all participants).

Participants were seated with their shoulders adducted and neutrally rotated, with the elbow flexed at 90°, the forearm in a neutral position, and the wrist between 0° and 30° of flexion and between 0° and 15° of ulnar deviation (Mathiowetz, 2002, p. 205). After having been positioned appropriately, participants were instructed to squeeze the dynamometer. Standard verbal reinforcement was given in Romanian: "Mai tare! . . . Mai tare! . . . Relaxeaza" ("Harder! . . . Harder! . . . Relax"; Mathiowetz, 2002, p. 205). Three measurements were taken for the right hand, and then three for the left hand, in alternating sequence to control for potential fatigue effects. The time between trials was about 15 s, which is the time needed to read and record each score. The mean of the three trials was then used for data analysis. After the measurement of the right hand with the first dynamometer, there was a timed 5-min interval until the right hand was tested again with the second dynamometer. The left hand was tested during this 5-min interval. On the basis of a previous study (Mathiowetz, 1990), the time between trials and between dynamometers represents the adequate amount of time to reduce the risk of fatigue (Mathiowetz, 2002).

Data Analysis

Data were analyzed using IBM SPSS Statistics (Version 25). The means of the three trials from each hand (three measures for the nondominant hand and three

Table 1. Participants' Demographic and MGS Data for Use of the Squegg® Smart Dynamometer and Hand Grip Trainer and the Jamar® Hydraulic Hand Dynamometer

	M (*SD*)		
Group	**Total Population (*N* = 40)**	**Male (*n* = 20)**	**Female (*n* = 20)**
Age	69.88 (7.9)	66.8 (6.6)	72.95 (8.04)
BMI	27.47 (4.83)	27.33 (3.54)	27.62 (5.94)
MMSE	28.70 (1.07)	29.15 (0.75)	28.40 (1.23)
MGS			
Dominant and nondominant hands			
Jamar	29.20 (10.42)	37.34 (7.88)	21.06 (4.66)
Squegg	29.20 (8.56)	34.80 (6.8)	23.60 (6.31)
Dominant hand			
Jamar	29.87 (10.17)	37.83 (7.57)	21.91 (4.62)
Squegg	30.02 (8.41)	35.51 (6.23)	24.54 (6.56)
Nondominant hand			
Jamar	28.53 (10.89)	36.84 (8.05)	20.21 (5.05)
Squegg	28.38 (8.98)	34.09 (7.44)	22.67 (6.46)

Note. BMI = body mass index; MGS = maximal grip strength; MMSE = Mini-Mental State Examination.

Table 2. **Properties of the Jamar® Hydraulic Hand Dynamometer and Squegg® Smart Dynamometer and Hand Grip Trainer**

Properties	Squegg Smart Dynamometer and Hand Grip Trainer	Jamar Hydraulic Hand Dynamometer
Weight	24 g	1.3 kg
Length	61 mm	49 mm
Width	31 mm	26 mm
Measurement units	kg or lbs. (set in the app)	kg or lbs. (dual scale readout)
Measuring modes	Isotonic and isometric	Isometric only
Increments of measurement	0.1 lbs. (0–220 lbs.)	5 lbs. (0–200 lbs.)
Readings (digital/nondigital)	App integration	Nondigital
Calculations	Maximum, mean, *SD*, isometric hold, left/right hand	Maximum grip
Data tracking/recording	Automatic through app	Not available/manual

Note. The Jamar dynamometer's adjustable handle was set to the recommended Position 2 (49 mm). Calculations and data tracking/recording reflect the capabilities of the app to calculate the maximum grip strength, mean grip, and standard deviation for an isometric hold of each user/participant for both their right and left hands. During the "evaluation" on the app, as part of the onboarding process, the user identifies which hand they are using and their hand dominance. The data are stored separately in the cloud-based system and is represented visually on the app separately, on the basis of the user's input at the time of evaluation. The device itself does not have the capacity to identify which hand the user/participant is using to hold the device.

for the dominant hand, alternating each hand) for both devices were used for data analysis. Data were checked for normality and symmetry using Shapiro-Wilks tests, histograms and QQ plots, skewness, and Levene's test for equality of variances.

The influence of which device was used first (starting device) to measure maximal grip strength (MGS) on overall mean MGS was analyzed using t tests for each device. We calculated the statistical differences in overall MGS between sexes (male vs. female) using t tests for each device. Paired-samples t tests were used to compare overall mean MGS, as well as the mean MGS for each hand, between the two devices.

The interinstrument reliability between the Jamar dynamometer and Squegg was analyzed using intraclass correlation (ICC). We calculated the ICC estimates and their 95% confidence intervals using IBM SPSS Statistics, on the basis of a mean rating ($k = 2$), absolute-agreement, two-way, mixed-effects model. ICCs of <.50, between .50 and .75, between .75 and .90, and >.90 indicate poor, moderate, good, and excellent reliability, respectively (Koo & Li, 2016). The ICC values were calculated for all data collectively, as well as separately for each hand. The correlation between the Jamar Dynamometer and Squegg measurements across all participants, age, and sex was also calculated using Pearson's correlation. It was assumed that $r < .3$ represented a negligible correlation; .3 to .5, a low correlation; .5 to .7, a moderate correlation; .7 to .9, a strong correlation; and >.9, a very strong correlation (Mukaka, 2012). Statistical significance was calculated at a 95% confidence interval ($p < .05$).

Results

Figure 1 shows the mean MGS for each hand on the three trials with each device.

Shapiro–Wilks tests did not show evidence of nonnormality (Jamar dynamometer: mean dominant hand, $p = .102$; mean nondominant hand, $p = .073$; Squegg device: mean dominant hand, $p = .988$; mean nondominant hand, $p = .738$). On the basis of this outcome, and after visual examination of the histogram of X (where X represents grip strength for each hand with each device) and the QQ plot, we decided to use a parametric test. There were no outliers in the data as assessed by inspection of boxplots. All variables have passed the normality assumption for skewness (see Table 3).

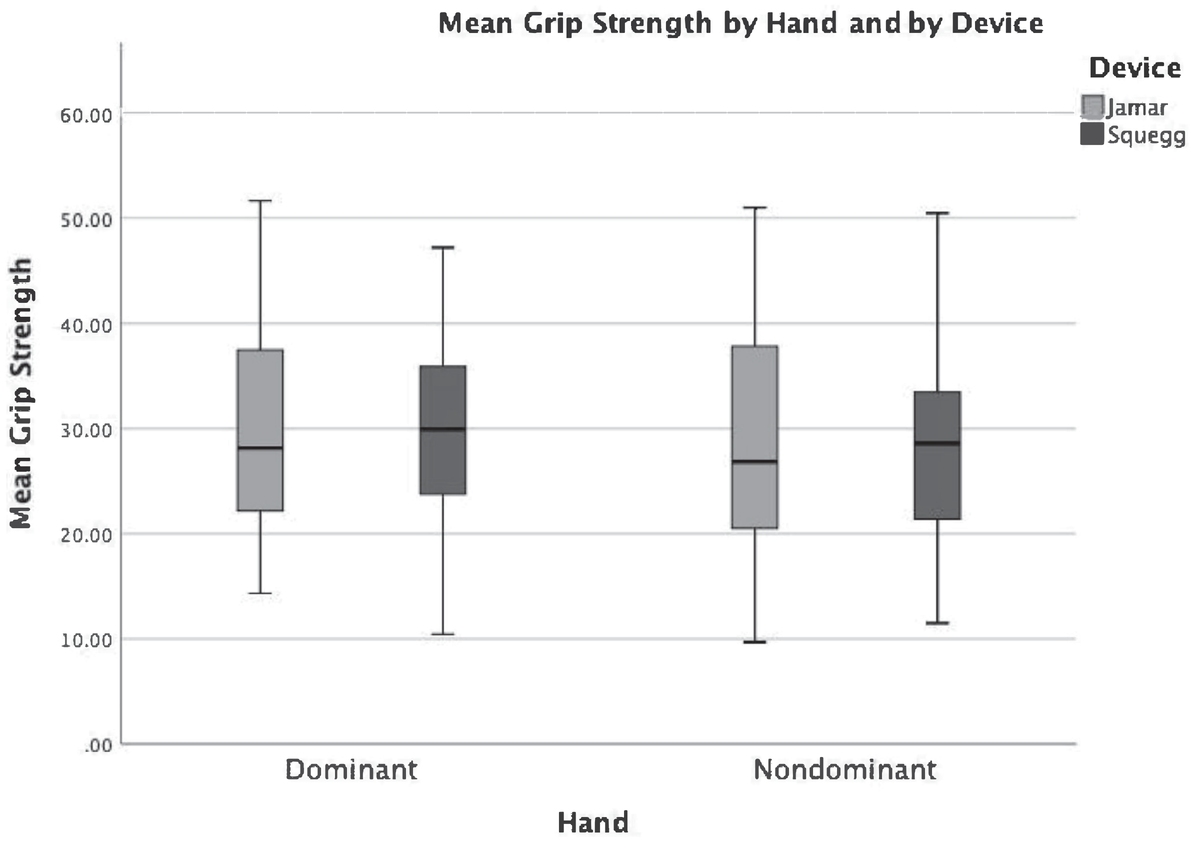
We found a homogeneity of variances for mean MGS scores for the Jamar dynamometer and the Squegg device as assessed by using Levene's test for equality of variances ($p = .116$).

There were significant differences in overall mean values for MGS between participants for whom the Jamar dynamometer was the starting device ($M = 25.64$, $SD = 7.2$) and those for whom the Squegg device was the starting device ($M = 32.77$, $SD = 9.64$), $t(35.16) = 2.65$, $p = .012$; which suggests that the starting device influenced the results.

Significant differences for sex were found with both instruments, with men having higher overall mean values for MGS compared with women ($p < .001$ for both instruments).

There were no significant differences between the overall mean scores for MGS as measured with the Jamar dynamometer ($M = 29.20$, $SD = 10.43$) and the Squegg device ($M = 29.21$, $SD = 8.56$), $t(39) = -.002$, $p = .988$; no difference between mean scores for the dominant hand as measured with the Jamar dynamometer ($M = 29.87$, $SD = 10.17$) and the Squegg device ($M = 30.03$, $SD = 8.41$), $t(39) = -.179$), $p = .859$; no difference between mean scores

Figure 1. Mean maximal grip strength for each hand by handgrip device.



Note. Jamar = Jamar® Hydraulic Hand Dynamometer; Squegg = Squegg® Smart Grip Trainer

for the nondominant hand as measured the Jamar dynamometer ($M = 28.53$, $SD = 10.89$) and the Squegg device ($M = 28.38$, $SD = 8.98$), $t(39) = .160$), $p = .874$. We used ICCs to test interinstrument reliability. The overall ICC value was computed across all data collectively, resulting in an overall ICC of .912 (95% CI [.83–.95]), which indicates a good to excellent interinstrument agreement between the two devices. The ICC was also calculated separately for hand results, indicating good to excellent interinstrument agreement between the two devices for both the dominant hand (ICC = .909; 95% CI = .83–.95) and the nondominant hand (ICC = .905; 95% CI [.82–.95]).

Table 3. Skewness for Maximal Grip Strength for Dominant and Nondominant Hands as Measured with the Jamar® Hydraulic Hand Dynamometer and Squegg® Smart Dynamometer and Hand Grip Trainer

Device and Hand Tested	Skewness	*SE*
Jamar dynamometer		
Dominant hand	.416	.374
Nondominant hand	.428	.374
Squegg Smart Grip Trainer		
Dominant hand	−.056	.374
Nondominant hand	.347	.374

Note. $N = 40$.

A Pearson correlation was calculated between the Jamar and Squegg device measurements across all subjects, age ranges, sex, and hands. The Pearson correlation coefficient, r, was .85, $p < .001$, indicating strong agreement between the two devices (Mukaka, 2012).

Discussion

The purpose of the present pilot study was to compare the interinstrument reliability and concurrent validity between the Squegg device and the gold-standard Jamar dynamometer (e.g., Allen & Barnett, 2011; Lee et al., 2020; Mathiowetz, 2002; Mutalib et al., 2022). Several previous studies that compared the Jamar dynamometer to other dynamometers have found higher MGS values for the former device. Massy-Westropp et al. (2004) evaluated MGS in normal adults, using the Jamar hydraulic dynamometer and the Grippit electronic dynamometer, and found that the electronic dynamometer was more able to detect smaller variances in grip strength compared with the Jamar dynamometer. Significantly higher MGS values for the Jamar device were reported even when the inter-device reliability was acceptable or good to excellent. Amaral et al. (2012) found a statistically significant difference between the Jamar dynamometer and the Takei electromechanical dynamometer, with the latter showing lower MGS values, whereas the inter-device reliability was acceptable. Lee et al. (2020) compared grip force measurements obtained using a digital hand dynamometer and with those obtained using the Jamar® standard dynamometer in younger and older adults. They found that grip force measurements that were obtained with the digital dynamometer were lower than, but strongly correlated with, those obtained with the Jamar dynamometer. A strong correlation was found in all participants and for both hands. This enabled the authors to develop a formula to convert values that were acquired using the MicroFET3 dynamometer to equivalent values acquired using the Jamar dynamometer. Mutalib et al. (2022) found that Grip-Able, a mobile handgrip device, provided lower MGS compared with Jamar PLUS+ but that the inter-device reliability was good to excellent. Previous studies propose that the differences in measurements between the Jamar and other electronic or digital devices might be attributable to different factors, such as the physical differences between the devices (Mutalib et al., 2022) and the position of the fingers on the device, which may influence grip strength (Amaral et al., 2012). Mutalib et al. (2022) have proposed that these differences may also be attributable to psychological factors such as participants' applying less force to devices that look more fragile. Our pilot study, however, did not find any significant statistical difference between the Squegg device and the Jamar dynamometer. In our sample, average values of MGS were similar for the two devices, for both dominant and nondominant hands. The analyzed dynamometers showed good to excellent ICCs (mean ICC $= .912$, $p = .001$). These promising preliminary results indicate that it is worth conducting a larger scale study to further evaluate the performance of the Squegg device and further establish the psychometric properties of the device to help inform best practice. Furthermore, our pilot study provides preliminary data such as the means and standard deviations necessary for power and sample size analysis for a larger trial.

Preserved handgrip strength is very important for independent living (Gopinath et al., 2017); unfortunately, the decline in this strength is insidious most of the time. Therefore, validating devices that would enable the frequent measurement of grip strength and sustained grip accurately, from the comfort of an individual's home, is extremely important in detecting early handgrip strength decline. The Squegg Smart Grip Trainer incorporates features (practicality, efficiency, and being a lower cost MGS instrument) that have the potential to cater to these needs.

Limitations

The main limitation of this study is the small sample size; however, in a pilot study only "a small sample size is usually required for estimation of ICC" (Bujang & Baharum, 2017, p. 4). Studies with larger sample sizes are still needed. As well as evaluations of other factors that will affect (remote) MGS testing, such as ergonomic properties, participants' reported ease of use, and differences in physical consistency of grip width in comparison with other devices. Finally, the present results may not generalize to younger adults or children, because they were not represented in this study. These samples could be included in future studies.

Although the present preliminary pilot study has shown that the Squegg device has good reliability and concurrent validity, compared with the Jamar, the ability to interchange dynamometers should never be assumed. This study used one of the many available Jamar dynamometers—specifically, the Jamar Hydraulic Hand Dynamometer. We cannot, therefore, assume that all Jamar dynamometers and Squegg devices measure equally unless their concurrent validity with known weights is acceptable (Mathiowetz, 2002). Specifically, two previous reports by Flood-Joy and Mathiowetz (1987) have provided evidence that different versions of the Jamar dynamometer do not always measure equivalently. Therefore, medical practitioners are encouraged to use the same dynamometer for the pre- and posttesting of patients (Mathiowetz, 2002).

Finally, during the reviewing process, it has been made known to us that the recommendation of wrist flexion for grip testing used in this study (as per Mathiowetz, 2002) is rather outdated. Future studies should use the third edition of the American Society of Hand Therapists' *Clinical Assessment Recommendations* (Schectman & Sindhu, 2015), which suggests wrist positioning in 0° to 30° of extension and 0° to 15° of ulnar deviation.

Directions for Future Research

First, because this is a pilot study, the interinstrument reliability and agreement and the concurrent validity between Jamar and Squegg devices should be assessed with a larger number of participants. Because one of the main benefits of the Squegg device is the ability to measure MGS remotely from the patient's home, further studies could assess the agreement between measurements taken under assisted conditions and measurements taken by patients alone. Future research should examine whether this method of capacity testing has any relation to actual hand function during the occupational performance or participation in activities of daily living and/or instrumental activities of daily living. Last, once device-specific normative values are available, including for age and sex subsets, they could be updated and integrated into the Squegg device's software for immediate comparison.

Implications for Occupational Therapy Practice

Occupational therapy practitioners need valid and reliable tools that support the innovative remote therapeutic assessment and monitoring of hand function, especially since the Covid-19 pandemic. Having such assessments available can provide occupational therapy practitioners the ability to evaluate the performance of hand function over time, as well as the effectiveness of an intervention, and can also help inform the creation of specific measurable attainable and timely treatment goals to aid in increased independence in performing meaningful basic and instrumental activities of daily living. The Squegg may be used for remote and clinical evaluations if future, larger studies show similar results.

Conclusion

Our study provides preliminary evidence that the Squegg device has good to excellent interinstrument reliability and agreement, as well as concurrent validity, as compared with the Jamar dynamometer for aging and older adults. The results from this pilot study, if supported by future research, suggest that the Squegg may be used for clinical evaluation and not just as a home training tool.

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