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Reliability of the use of Camry versus Jamar dynamometer

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Abstract

The Jamar hydraulic hand dynamometer is a valid and reliable but high-cost manual device commonly used to evaluate hand grip strength (HGS). Currently, digital dynamometers with automatic calibration, such as Camry, have been proposed as a more appropriate alternative for HGS evaluation. This study aimed to compare the outcome measures of Camry and Jamar dynamometers in healthy adults and to investigate the reliability and validity of Camry devices. This cross-sectional study employed a random crossover method. Bilateral HGS data were collected from 78 participants (37 males and 41 females) using the Camry and Jamar dynamometers and compared. Correlation analysis between the measurements was performed to determine the validity and reliability of the Camry dynamometer. A strong positive correlation was found between the Jamar and Camry devices for right-left average and maximum HGS measures (right average HGS: r=0.959, p=0.000; right maximum HGS: r=0.958, p=0.000; left average HGS: r=0.948, p=0.000; left maximum HGS: r=0.944, p=0.000). The intra-class correlation coefficient for consistency between the device's HGS measures was >97%. The Camry dynamometer provides excellent reliability and validity for evaluating HGS in healthy adults in Türkiye. This device can be easily used in clinical settings and academic research owing to its digital nature, which is practical, easy, and cost-effective.

Keywords: Hand strength, hand, devices, reliability, validity

Introduction

Hands play a critical role in daily activities with a coordinated combination of biomechanical, sensory, and motor parameters [1,2]. Hand grip strength (HGS) measurement is a commonly used approach for evaluating general health of the body and muscle power [3-5]. A decrease in HGS is a risk factor for the healthy life of an individual [3].

The HGS parameter is accepted as a reference for objective evaluation of hand function [4,6]. Various dynamometers are preferred for HGS evaluation [7], with units reported in kilograms (kg), Lbs (pounds), or Newtons (N) [8]. The Jamar hydraulic hand dynamometer is recommended by the American Association of Hand Therapists (ASHT), for evaluating HGS [9].

The Jamar dynamometer, which is used in clinics and research for evaluating HGS, is considered the gold standard due to its reliability and validity [10]. However, the limited grip contact area of the Jamar dynamometer may cause discomfort and influence HGS measurement [11]. In addition, its high cost and manual features are thought to hinder the efficiency in clinical assessments. Currently, the use of digital dynamometers with automatic calibration, automatic grip power data recording, and continuous data collection is considered more appropriate for the evaluation of HGS [7].

Despite their advantages, studies investigating the use of Camry digital dynamometers for HGS evaluation, particularly in healthy adults, remain limited [12,13]. This study aimed to compare the performance of the Camry and Jamar dynamometer in the evaluation of HGS in healthy adult in Türkiye and to investigate the reliability and validity of Camry device.

Material and Methods

Study Design

This cross-sectional study employed a randomized crossover method to assess HGS using two different dynamometers. Ethical approval was obtained from the Institutional Review Board of the İstanbul Medipol University (approval number: E-10840098-

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772.02-1541) on December 03, 2022. The study was conducted in accordance with the Declaration of Helsinki and approved by the registration number NCT06126211 (www. clinicaltrials. gov). Seventy-eight participants who met the inclusion criteria were randomly allocated to two groups. The participants were divided into two groups of 39 participants each using a 1:1 ratio, based on an Excel random number table. According to this allocation, participants numbered 1 were assigned to Group A for initial evaluation using the Camry dynamometer. Participants numbered 2 were assigned to Group B for initial evaluation using the Jamar dynamometer. The primary assessments were recorded for both groups. For the second assessment, both groups were crossed, with participants from Group A reassigned to Group B and vice versa. Secondary assessments were recorded accordingly [12,14]. The randomisation process was overseen by an investigator who was not involved in the assessments.

Participants

The participants in this study were healthy male and female individuals aged >18 years who voluntarily participated between March and June 2022, and were informed about the study. The participants were assessed at the İstanbul Medipol University Orthotic Prosthesis Centre (POMER). All participants signed an informed consent form prepared in accordance with the Declaration of Helsinki [15]. Inclusion criteria required participants to be older than 18 years and without any history of upper extremity surgery, fractures, or functional limitations. Exclusion criteria included any cognitive, psychological, or autoimmune disorder; used of assistive devices; hospitalizations exceeding three days within the past six months; or pregnancy.

To determine the required sample size, the study conducted by Lupton-Smith et al. [16] was used as a reference, and power analysis was performed. The 0.94 minimum consistency between the Camry and Jamar dynamometers and 0.97 overall consistency was calculated using the Sample Size Calculator program. Accordingly, the required sample size was determined to be 73 individuals with 85% power and 5% type I error. Considering a 15% dropout rate, the sample size was increased to 83 participants. Ultimately, 83 participants (41 males and 42 females) who met the inclusion criteria were initially recruited, but five withdrew, leaving the final sample size of 78 participants (37 males and 41 females). A flow diagram of the study is shown in Figure 1.

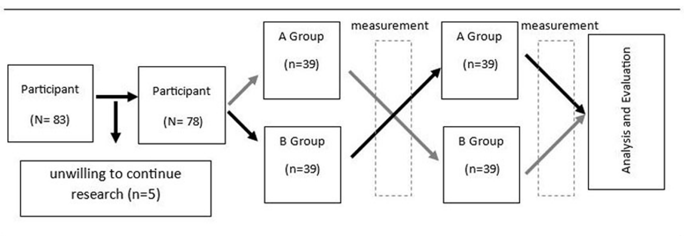

Figure 1. Study flow diagram; Group A: Camry dynamometer group, Group B: Jamar dynamometer group

Study Interventions

The use of the two dynamometers was explained in detail to the participants. HGS of each participant was measured using an electronic Camry dynamometer (Model EH101, Zhongshan Camry Electronic Co., Ltd., China: 90 kg capacity, 356 g weight) and a Jamar Hydraulic Hand Grip Dynamometer (Model J00105, Lafayette Instrument Company, USA: 90 kg capacity, 727 g weight) (Figure 2). Upper-extremity assessments were performed bilaterally. The dominant upper extremities of the participants were noted, and the applied evaluations were recorded simultaneously. During the evaluation, performed using both dynamometers, three different measurements were recorded for both the right and left upper extremities. Rest intervals of one minute (60 s) were provided between each measurement, and a 10-min interval between the two different dynamometer measurements [12]. Each measurement recorded the maximum and average values for statistical analysis. The measurements were carried out by a single researcher at the same centre.

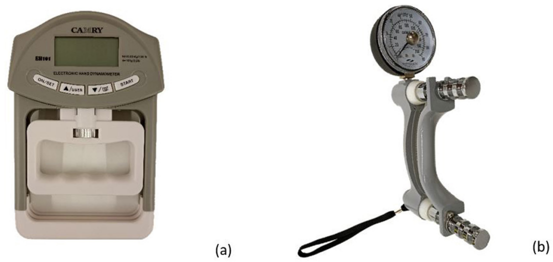

Figure 2. Camry dynamometer (Model EH101) (**a**) and Jamar dynamometer (Model J00105) (**b**)

The posture of the participant during evaluation was adjusted as follows: feet were aligned at shoulder width and relaxed; shoulders in neutral rotation-vertical adduction; elbow in 90° flexion; forearms in neutral position; and wrist in 0°–30° extension with 0°–15° ulnar deviation (Figure 3) [12,17,18]. This position was also recommended in the guidelines published by the ASHT for standard HGS assessment [9]. Once the proper posture was achieved, participants were instructed to perform maximum grip movement for 5 s.

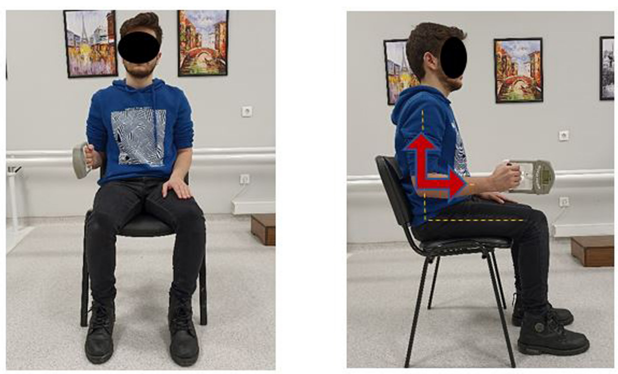

Figure 3. The grip strength assessment posture of the participants (anterior and lateral aspects)

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Statistical Analysis

The data obtained from the study were analyzed in a computer environment using SPSS 22.0. Frequency and percentage analyses were performed to determine the descriptive features of the included participants, and average and standard deviation statistics were used to evaluate scales. Differences between measurement methods were analyzed using an independent Student's t-test. Statistical significance was set at a 95% confidence interval (p<0.05). For test-retest reliability was assessed using the intraclass correlation coefficient (ICC), with values ranging from 0.00 to 1.00 and values between 0.60 and 0.80 indicated good reliability, while values >0.80 indicated excellent results [19].

Results

A total of 83 individuals (42 female and 41 male) who met the inclusion criteria were initially included in the study. However, five participants who chose to leave were excluded, resulting in a final sample size of 78 participants (41 females and 37 males). The average age of the participants was 21.46±1.99 years (minimum=18; maximum=30), and their average body mass index (BMI) was 22.34±3.43 (minimum=16.94; maximum=34.33). The right hand was identified as the dominant hand in 100% of the female (n=41) participants and 94.5% of the male (n=35) participants.

A comparison of the average and maximum HGS measurements according to sex is presented in Table 1. Across all participants, the HGS values obtained using the Jamar dynamometer were higher than those measured using the Camry dynamometer for both hands. In female participants, statistically significant differences were observed in the average and maximum HGS values of both hands (right and left) when measured with Jamar device (right-hand average HGS: t=3.149, p=0.003 and maximum HGS: t=3.893, p=0.000; left-hand average HGS: t=4.915, p=0.000 and maximum HGS: t=6.416, p=0.000). Figure 4 shows the maximum and average HGS values obtained from each device for the female participants. In male participants, a statistically significant difference was observed in the maximum HGS values for both right and left hands (right hand maximum HGS: t=3.319, p=0.002; left hand maxi-mum HGS: t=2.333, p=0.025), but not in the average HGS for either hand (p>0.05). Figure 5 shows the maximum and average HGS values obtained from each device for the male participants. When the Jamar and Camry HGS outcomes of all participants were compared, statistically significant differences were observed in the average and maximum HGS values of both hands (right-hand average HGS: t=3.511, p=0.001 and maximum HGS: t=5.084, p=0.000; left-hand average HGS: t=3.449, p=0.001 and maximum HGS: t=5.582, p=0.000). Figure 6 shows the maximum and average HGS values obtained from each device for all participants.

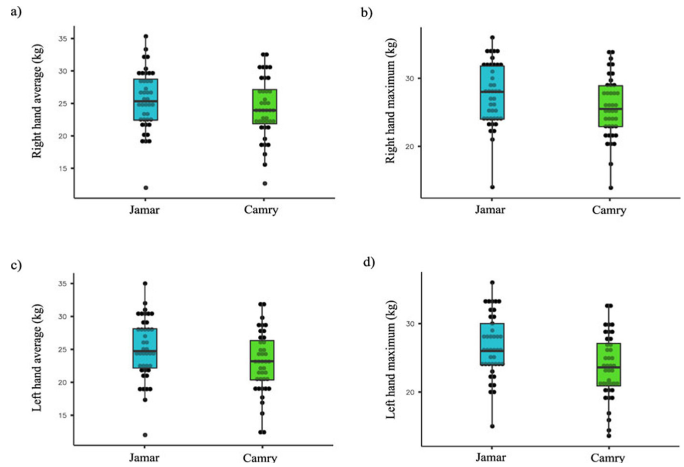

Figure 4. Measurements using Jamar and Camry dynamometer for right hand average HGS (**a**); right hand maximum HGS (**b**); left hand average HGS (**c**) and left hand maximum HGS (**d**) of female participants (Wilcoxon signed rank test; p<0.001 for all)

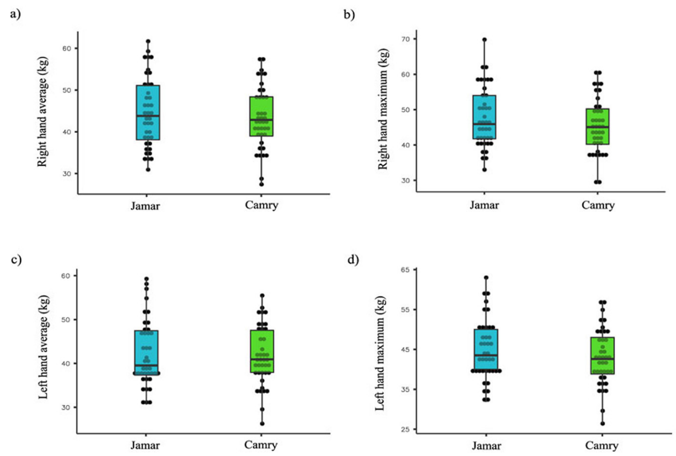

Figure 5. Measurements using Jamar and Camry dynamometer for right hand average HGS (**a**); right hand maximum HGS (**b**); left hand average HGS (**c**) and left hand maximum HGS (**d**) of male participants (Wilcoxon signed rank test; p<0.001 for all)

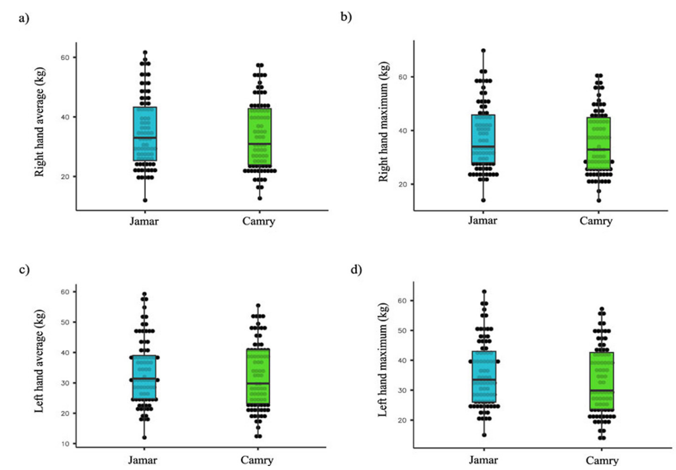

Figure 6. Measurements using Jamar and Camry dynamometer for right hand average HGS (**a**); right hand maximum HGS (**b**); left hand average HGS (**c**) and left hand maximum HGS (**d**) of all participants (Wilcoxon signed rank test; p<0.001 for all)

Table 1. Comparison of Jamar and Camry hand grip strengths by gender

Hand Grip Strengths (kg)		Female (n=41)		Male (n=37)		Total (N=78)	
		Right Mean±SD	Left Mean±SD	Right Mean±SD	Left Mean±SD	Right Mean±SD	Left Mean±SD
Average	Jamar	25.54±4.61	25.01±4.70	45.02±8.29	42.50±7.54	34.78±11.79	33.31±10.74
	Camry	24.13±4.55	22.93±4.65	43.77±7.20	41.91±6.60	33.45±11.51	31.93±11.07
	p	0.003	0.000	0.057	0.389	0.001	0.001
Maximum	Jamar	27.59±4.59	26.69±4.53	48.11±8.46	44.99±7.44	37.32±12.28	35.37±11.00
	Camry	25.66±4.45	23.68±4.63	45.98±7.56	43.29±6.90	35.30±11.88	32.98±11.42
	p	0.000	0.000	0.002	0.025	0.000	0.000

SD: standard deviation, n: number of participants, N: total number of participants

Correlation analysis between the Jamar and Camry dynamometers is presented in Table 2. A high positive correlation was observed between average and maximum HGS values measured by the two devices for both hands (right and left) (right average HGS: r=0.959, p=0.000 and maximum HGS: r=0.958, p=0.000; left average HGS: r=0.948, p=0.000 and maximum HGS: r=0.944, p=0.000).

Table 2. Correlation analysis between Jamar and Camry HGS measurements

			Jamar Right HGS		Jamar Left HGS	
			Mean	Maximum	Mean	Maximum
Camry Right HGS	Average	r	0.959**			
		p	0.000			
	Maximum	r		0.958**		
		p		0.000		
Camry Left HGS	Average	r			0.948**	
		p			0.000	
	Maximum	r				0.944**
		p				0.000

*<0.05; **<0.01; Correlation Analysis; HGS: hand grip strength

ICC analysis results between the total right- and left-hand HGS measurements obtained using Jamar and Camry dynamometers are presented in Table 3. The ICC analysis for consistency between the Jamar and Camry HGS measurements was >97%.

Table 3. Jamar and Camry total right and left HGS intra-class correlation analysis

	ICC	ICC (Confidence interval 95%)	F	p
Right HGS	0.979	0.967-0.987	47.659	0.000
Left HGS	0.973	0.958-0.983	37.481	0.000

HGS: hand grip strength, ICC: intra-class correlation coefficient; ICC=0.60-0.80 with good reliability; ICC>0.80 your reliability is excellent

Discussion

In this cross-sectional study, Camry and Jamar dynamometers were compared for the evaluation of HGS in healthy adults in Türkiye, and the reliability and validity of the Camry dynamometer were investigated. However, this is a preliminary study that investigated the relationship between the Camry and Jamar dynamometer.

HGS is reportedly related to general muscle strength, physical activity levels, and overall health [20-22]. HGS evaluation in all healthy and/or diseased individuals is important for clinical follow-up and evaluation.

HGS testing, which is relatively easy and inexpensive, has been shown to be a valid and reliable assessment tool for both healthy and diseased individuals [23]. Grip strength is an important indicator of clinical outcomes in a wide range of health conditions [24] and is the most commonly used physical measure by hand surgeons and researchers to determine overall upper limb function. The test is easy to perform, and its reliability and normative values are well established [25].

The Jamar dynamometer is the most frequently used and preferred evaluation device in clinics for HGS evaluation due to its proven validity and reliability in the literature [10].

Therefore, numerous studies have examined the reliability of HGS measurements using the Jamar and other dynamometers [7,26,27]. Compared to Jamar dynamometers, the Camry dynamometer is less expensive and more readily. In a study by De Dobbeleer et al. (2018), the Jamar dynamometer was found to be more difficult to use and time-consuming than other electronic dynamometers [26]. One of the greatest differences between Jamar and electronic dynamometers is the display screen. When evaluating HGS, the Camry dynamometer displays the results on a digital screen, whereas the Jamar dynamometer displays such results in an analog form that may require evaluators to estimate results when values fall between two markings [28]. A limited number of studies have assessed the Jamar dynamometer for HGS measurement; therefore, its validity in different populations remains unclear [29].

It is essential to investigate the reliability of different electronic dynamometers in the assessment of HGS. These valid measuring devices should be accessible, cost-effective, and technologically and ergonomically appropriate. Based on results of our study, which align with previous findings, and the proven reliability of Camry dynamometer, we believe that it could be used more widely as an objective evaluation method in clinical and academic research.

Consistent with previous studies comparing HGS measurements across different dynamometers, higher measurements were observed using the Jamar dynamometer in our study [30,31]. Diffrences in the grip components of the two dynamometers may also infuluence the results. For example, any displacement of the gripping part during testing could reduce the applied effort. Additionally, the lack of tactile feedback in the Jamar dynamometer mechanism may lead to firmer grip [30]. Other studies comparing the Jamar with the MyoGrip and Takei hand dynamometers re-ported larger discrepancies than those observed between the Jamar and Camry in our study [30,31]. According to the results of this study, the differences in maximum and average HGS values between the Camry and Jamar dynamometers were much lower. These results are attributed to the hydraulic and heavier mechanisms of the Jamar dy-namometer. We also hypothesized that individuals exerted greater effort due to sensory input against the instant response to fluid in the hydraulic mechanism. In addition, the heavier weight of the Jamar dynamometer may have contributed to the increased effort during testing.

In studies that aimed to determine the reliability of dynamometers for HGS measurements, the correlation between the two devices was primarily evaluated [32,33]. Consistent with other studies comparing Jamar and other dynamometers, a high correlation was found in HGS measurements between Jamar and Camry dynamometers in our study [33]. Owing to its light weight, portable features, easy usage, and digital measurement advantages, the camera dynamometer is thought to be preferable in clinical settings for the evaluation of HGS.

When HGS was investigated according to physiological and sex parameters, males exhibited higher HGS scores than females, aligning with previously reported findings [34]. HGS has been shown to correlate not only with sex but also with factors such as nutrition, lifestyle, culture, environment, and genetics [35]. In recent years, a relationship among HGS, cognitive factors, and sleep quality has also been reported [36]. For these reasons, it was thought that HGS could also be affected by concrete and intangible factors, and HGS should be studied in more detail in the future. According to the literature, different elbow positions has affected the HGS, and in our study, such measurements were performed with participants' elbow flexion at 90° [37]. We aimed to increase the accuracy of our study results by measuring HGS in the same environ-ment, chair, and position for each participant.

In a study investigating normative HGS values in males and females across different age groups, it was reported that male between ages 18–24 years, weight 47.0 kg and female weight 28.1 kg on the dominant side while the male individuals weight 44.9 kg and female weight 26.6 kg on the non-dominant side. The right and left maximum HGS results obtained using the Jamar dynamometer in our study were consistent with those in the literature [38]. Among the participants included in our study, 100% of the females and 94.5% of the males identified their dominant side as the right hand. The higher number of participants with right side dominance did not negatively affect our study results, and the reliability (average 97%) of the ICC for the right and left hands was excellent [19]. In a review and metaanalysis released in 2016, they stated that HGS in males and females can increase up to the age of 39 years and decrease markedly after the age of 60 years, and the results may vary significantly involving different age groups [39]. A strength of this study was the inclusion of healthy individuals within a homogeneous age range, which increased the reliability of our results.

Our study had certain limitations. First, although individuals >18 years were included, their average age was 21 years. Second, the professional status of participants was not questioned. Future studies should examine and compare HGS across different age groups and professional cohorts to further inform the use of the Camry dynamometer in clinical practice.

Conclusion

In conclusion, this study demonstrated that the Camry dynamometer, when applied to healthy individuals, showed a high correlation with the Jamar dynamometer, which is accepted as a gold standard in HGS measurement. The Jamar dynamometer is a manual assessment tool that may result in disparate outcomes among assessors. We believe that the Camry dynamometer, with its numerical data displayed on a digital screen, is modern assessment tool. It can be reliably used in clinical and academic research and provides an objective comparison of hand grip strength after conservative and surgical interventions. The practical of its use and user-friendly digital screen are among the important features that make this device preferable.

Conflict of Interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical Approval
Ethics committee approval was received for this study from the ethics committee of İstanbul Medipol University, Türkiye (Date: December 03, 2022, Number: E-10840098-772.02-1541). It was registered in the clinical trial registry (www.clinicaltrials.gov, clinical ID No: NCT06126211).

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