



Research Article/Özgün Araştırma

Validity and reliability of using a low-cost handgrip dynamometer in healthy adults

Sağlıklı yetişkinlerde düşük maliyetli el kavrama dinamometresinin kullanımının geçerlik ve güvenilirliği

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**Abstract**

**Aim:** To evaluate the concurrent validity, test-retest reliability, and repeatability of the Camry digital hand dynamometer compared with the Jamar® hydraulic hand dynamometer in healthy adults.

**Materials and Methods:** 154 healthy participants participated. Handgrip strength was assessed using the Jamar and Camry devices. Statistical analyses included the Spearman correlation coefficients, Bland-Altman analysis, Wilcoxon signed-rank test, intraclass correlation coefficient (ICC), and repeatability metrics (coefficient of variation, CV), standard error of measurement, minimal detectable change.

**Results:** The Camry demonstrated strong correlations with the Jamar for both hands at both test and retest sessions ( $r>0.90$ ,  $p<0.001$ ). Test-retest reliability was excellent for both devices ( $ICC\geq 0.98$ ). Repeatability indices for both devices (CV 8–10%) were within the accepted range for dynamometry.

**Conclusion:** The Camry is a valid, reliable, and cost-effective alternative to the Jamar for assessing handgrip strength in healthy adults.

**Keywords:** Handgrip strength; Dynamometer; Validity; Reliability; Repeatability.

**Öz**

**Amaç:** Sağlıklı yetişkinlerde Camry dijital el dinamometresinin geçerlilik, test-tekrar test güvenilirliği ve tekrarlanabilirliğini, Jamar® hidrolik el dinamometresi ile karşılaştırarak değerlendirmek.

**Gereç ve Yöntemler:** 154 sağlıklı yetişkin çalışmaya dahil edildi. Dominant ve nondominant el kavrama kuvveti ölçümleri Jamar ve Camry cihazları ile yapıldı. İstatistiksel analizlerde Spearman korelasyon katsayısı, Bland-Altman analizi, Wilcoxon işaretli sıra testi, intraclass korelasyon katsayısı (ICC) ve tekrarlanabilirlik ölçütleri (varyasyon katsayısı (CV), ölçümün standart hatası (SEM), minimal belirlenebilir değişim kullanıldı.

**Bulgular:** Camry, her iki elde ve her iki ölçüm zamanında Jamar ile güçlü korelasyon gösterdi ( $r>0.90$ ,  $p<0.001$ ). Test-tekrar test güvenilirliği her iki cihaz için mükemmel düzeydeydi ( $ICC\geq 0.98$ ). Her iki cihaz için CV değerleri (%8–10) kabul edilen aralıkta idi.

**Sonuç:** Camry dinamometresi, sağlıklı yetişkinlerde el kavrama kuvveti ölçümü için geçerli, güvenilir ve maliyet-etkin bir alternatiftir.

**Anahtar Kelimeler:** El kavrama kuvveti; Dinamometre; Geçerlilik; Güvenirlik; Tekrarlanabilirlik.

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## Introduction

Handgrip strength is a widely recognized, valid, and reliable indicator of physical function, serving as a key marker of overall health and a predictor of clinical outcomes across various conditions.<sup>1,2</sup> As a simple and objective measure of hand and upper limb function, handgrip strength reflects the capacity required for daily self-care, occupational tasks, and leisure activities.<sup>3</sup> Owing to its broad clinical applicability, handgrip strength testing is routinely used by health professionals in diverse healthcare settings. As a strong correlate of overall muscular strength, it provides a robust indicator of current health status and a predictor of age-related diseases and functional decline.<sup>2</sup> Its measurement is therefore essential not only for monitoring disease progression and rehabilitation outcomes but also for evaluating performance in healthy populations to support benchmarking and longitudinal tracking.<sup>3,4</sup>

An accurate and reliable instrument for measuring is essential for ensuring both the precision of grip assessments and the validity of clinical interpretations. Handgrip strength is typically measured with a handgrip device equipped with a force or pressure sensor, known as a dynamometer.<sup>5</sup> Isometric dynamometers represent a practical and widely accepted method for assessing handgrip strength across all age groups. Along with the most widely used and well-known device, the Jamar®, several other dynamometers have also been introduced that exhibit good-to-excellent inter-instrument reliability when compared with this gold-standard device. These instruments include the Baseline, Citec, Rolyan, MyoGrip and Bodygrip dynamometers.<sup>5-8</sup>

The Jamar® Hydraulic Hand Dynamometer is considered the gold standard for grip strength assessment by the American Society of Hand Therapists due to its high validity and reliability.<sup>9,10</sup> It has been widely used in numerous studies, including the well-known normative grip-strength investigations in adults and children, which continue to guide clinicians worldwide when comparing patients' grip strength.<sup>10,11</sup> However, Jamar®

is a manual, analog device with a relatively high cost and substantial weight (1,360 g), which limits its accessibility in certain settings. Although a digital version, Jamar Plus+, is available, its cost is even higher (727 g).<sup>12</sup> In contrast, the Camry digital hand dynamometer is approximately ten times less expensive, significantly lighter (356 g), and offers automatic calibration.<sup>13</sup> Despite its increasing use in clinical and research contexts worldwide,<sup>14-16</sup> its validity and reliability have not been examined in the healthy Turkish population.<sup>16,17</sup>

A validity and reliability study in a healthy population is essential because the resulting data may serve as reference values for future investigations assessing grip strength in adults with various diseases. Conducting this study specifically in the Turkish population is important to account for anthropometric and lifestyle differences from other countries, which may influence normative grip strength values.<sup>18,19</sup>

Therefore, the aim of this study was to evaluate the concurrent validity of the Camry digital hand dynamometer by comparing it with the Jamar® Hydraulic Hand Dynamometer in healthy adults.

## Materials and Methods

### Study design

This study was designed as a cross-sectional and conducted between February and July 2025 at the Department of Physiotherapy and Rehabilitation, Yalova University.

### Study group

Staff and students at Yalova University were invited to participate voluntarily in this study via e-mail. The institution's social media accounts were also used to extend the invitation.

Based on the data collected from 154 participants, a post hoc power analysis was conducted using the observed correlation between the JAMAR and CAMRY dynamometers for the dominant hand ( $r = 0.905$ ).<sup>20</sup> The analysis was performed in G\*Power 3.1 using the Exact test family (Correlation—Bivariate normal model) with  $\alpha = 0.05$ , two-tailed. The calculated statistical

power exceeded 0.99, confirming that the current sample size was sufficient to estimate the correlation with high precision.<sup>21</sup>

Voluntary participants who met the inclusion criteria were recruited from the healthy adult population at Yalova University. Inclusion criteria were as follows:

- Individuals aged between 18 and 65 years,
- Both male and female participants.

Exclusion criteria included:

- Use of any assistive devices,
- Diagnosis of rheumatoid arthritis, gout, neuromuscular disorders, or any acute or chronic condition that may affect grip strength,
- Pregnancy,
- History of subluxation, dislocation, or fracture in the upper extremity,
- Diagnosis of Type 1 or Type 2 diabetes mellitus,
- Presence of unstable chronic or systemic diseases.

### Dependent and independent variables

The independent variables were age, body mass index (BMI), gender, dominant side, level of education, working status, and preferred device for comfort. The dependent variables were the maximum handgrip strengths of the dominant and nondominant sides. Participants' sociodemographic data were collected using an "Assessment Form."

### Measurement of handgrip strength

Handgrip strength was measured using both the Jamar Hydraulic Hand Dynamometer and the Camry Digital Hand Dynamometer.

Prior to testing, participants were informed about the procedure and devices. One of the two experienced investigators provided standardized instructions, recorded demographic information and determined each participant's hand dominance, defined as the preferred hand for well-practiced motor tasks (e.g., writing, using forks/spoons, throwing a ball).

All dynamometer measurements were performed by the same investigator to ensure consistency. Each participant performed three

maximal grip strength trials with both the Jamar and Camry devices for each hand. The Jamar dynamometer was set to the second-handle position, which maximizes grip strength reliability.<sup>14,15,22</sup> To match this grip span, the Camry handle was adjusted to 5 cm. A 10-minute rest interval was provided between device measurements to prevent fatigue. The order of device testing and the order of hand tested were randomized in a 1:1 ratio using a sealed-envelope method.

For test-retest reliability analysis, measurements were repeated seven days after the initial session on the same participants. All assessments followed the standardized protocol of the American Society of Hand Therapists: the participant seated with the shoulder in a neutral position, feet flat on the floor, elbow flexed at 90°, and forearm in a neutral position.<sup>4</sup> Participants were instructed to exert maximal effort while gripping the device, with verbal encouragement provided to optimize performance. Each measurement was repeated three times with a one-minute rest interval; the average value (in kilograms) was recorded for each hand.<sup>23</sup>

To maintain participant blinding, measurement readings were concealed from participants; however, researchers were not blinded to the results. After completing measurements with both devices, participants were asked to indicate which device they found more comfortable to use.

### Statistical analysis

All analyses were performed using IBM SPSS Statistics 24.0 (IBM, USA). Descriptive statistics were reported as mean  $\pm$  standard deviation (SD) and frequency (%). Data distribution was assessed using the Shapiro-Wilk test, which revealed that all measurement differences deviated from normality ( $p < 0.001$ ).

For assessing concurrent validity between devices and test-retest reliability within devices, the Spearman correlation coefficient ( $r$ ) was calculated. Correlation strength was interpreted as follows:  $r < 0.30$  poor, 0.30–0.50 fair, 0.50–0.70 moderate, and  $> 0.70$  strong.<sup>24</sup> Bland-Altman analysis was used to evaluate the distribution of differences between

devices. The bias was defined as the mean difference between devices, and the 95% limits of agreement (LoA) were calculated using the following formula:<sup>25</sup>

$$\text{LoA} = \text{Bias} \pm 1.96 \times \text{SD} (\text{Mean1} - \text{Mean2})$$

To compare repeated measurements within the same device and across devices at different time points, the Wilcoxon signed-rank test was used. Statistical significance was set at  $p < 0.05$ .

Test-retest reliability was assessed using the Intraclass Correlation Coefficient (ICC, two-way mixed-effects, absolute agreement, average measures). ICC values were interpreted as follows:  $< 0.50$  poor,  $0.50-0.75$  moderate,  $0.75-0.90$  good, and  $> 0.90$  excellent reliability.<sup>26</sup>

Repeatability was further examined using the Standard Error of Measurement (SEM), Minimal Detectable Change (MDC), MDC%, and Coefficient of Variation (CV). These were calculated using the following formulas:<sup>25,27</sup>

$$\text{SEM} = (\text{SD1} + \text{SD2}) / 2 \times \sqrt{(1 - \text{ICC})}$$

$$\text{MDC} = \text{SEM} \times 1.96 \times \sqrt{2}$$

$$\text{MDC \%} = \text{MDC} / (\text{Mean1} + \text{Mean 2}) / 2 \times 100$$

$$\text{CV \%} = (\text{SD} (\text{Mean 2} - \text{Mean 1}) / (\text{Mean1} + \text{Mean 2}) / 2) \times 100$$

### Ethics committee approval

This study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Non-Interventional Research Ethics Board at Yalova University in December 2024 (study protocol: 2024/293). This study was registered in ClinicalTrials.gov (NCT06845072). All participants provided written informed consent prior to participating.

### Results

One hundred fifty-four participants were enrolled in the study. Participants' age, gender, dominant hand, BMI, physical activity and sedentary levels, as well as their preferred device for comfort, are presented in Table 1.

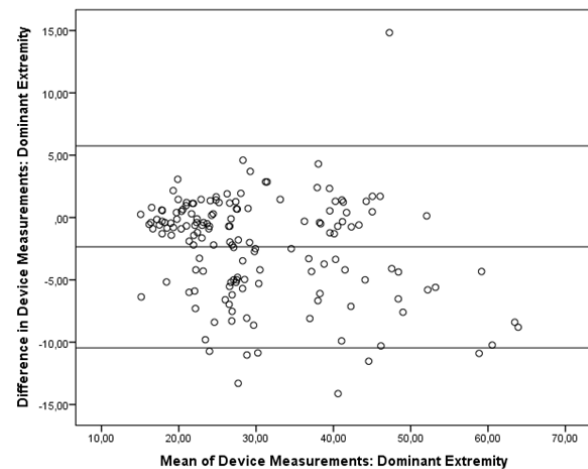
**Table 1.** Participants' demographic features.

Variables	n = 154
	Mean $\pm$ SD (min-max)
Age (Years)	23.90 $\pm$ 6.07 (18-60)
BMI (kg/m <sup>2</sup> )	23.38 $\pm$ 3.31 (17.85-33.66)
Gender	n (%)
Female	102 (66.2%)
Male	52 (33.8%)
Dominant Side	n (%)
Right	149 (96.8%)
Left	5 (3.2%)
Level of Education	n (%)
High school	80 (51.9%)
Bachelor	43 (27.8%)
Postgraduate	31 (20.3%)
Working Status	n (%)
Employed	16 (10.4%)
Unemployed	5 (3.2%)
Student	133 (86.4%)
Comfortable Device Selection	n (%)
Jamar	55 (35.7%)
Camry	99 (64.3%)

BMI: Body mass index, kg: Kilogram, m: Meter, SD: Standard deviation, %: Frequency

### Concurrent validity

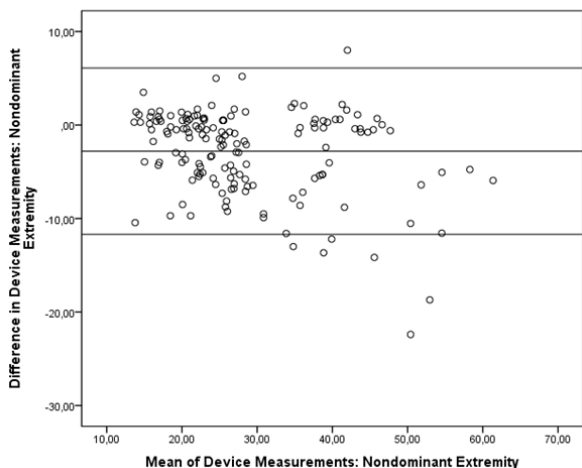
In the Bland-Altman analysis for dominant hand measurements, the mean difference (bias) between the Camry and Jamar dynamometers was  $-2.32$  kg, with 95% limits of agreement ranging from  $-10.46$  kg to  $+5.81$  kg (Figure 1). For the nondominant hand, the mean difference was  $-2.80$  kg, with limits of agreement ranging from  $-11.70$  kg to  $+6.10$  kg (Figure 2). No proportional bias was observed in the dominant hand, whereas a slight increase in differences at higher measurement values was noted for the nondominant hand.



**Figure 1.** Bland-Altman plot for dominant hand grip strength.

The X-axis represents the mean grip strength of the Jamar and Camry dynamometers, and the Y-axis shows their measurement difference. The central line indicates bias, while the upper and lower lines

represent the 95% limits of agreement. Most points fall within these limits, with no evident proportional bias.



**Figure 2.** Bland–Altman plot for nondominant hand grip strength.

The X-axis shows the mean grip strength of both devices, and the Y-axis shows their difference. The central line represents the bias, and the upper and lower lines indicate the 95% limits of agreement. Most points fall within these limits without evident proportional bias.

Spearman correlation coefficients indicated strong associations both within and between devices. For the dominant hand, the within-device test–retest correlations were  $r = 0.956$  for the JAMAR and  $r = 0.964$  for the CAMRY (both  $p < 0.001$ ). For the nondominant hand, the corresponding values were  $r = 0.964$  and  $r = 0.957$  (both  $p < 0.001$ ). Between-device correlations were  $r = 0.905$  and  $r = 0.918$  for the dominant hand (test and retest, respectively), and  $r = 0.910$  and  $r = 0.919$  for the nondominant hand (test and retest, respectively), all

$p < 0.001$ . These results indicate excellent test–retest reliability and high consistency between devices, confirming the repeatability of grip strength measurements across both hands and supporting the use of the CAMRY dynamometer as a reliable alternative to the JAMAR. Detailed correlation and Wilcoxon signed-rank test results are presented in Table 2. Analysis showed no statistically significant differences between repeated measurements within the same device (Jamar test–retest and Camry test–retest) for either hand ( $p > 0.05$ ). However, a statistically significant difference was found between Jamar and Camry measurements at the same time points for both hands ( $p < 0.001$ ). Additionally, when comparing the change scores (retest–test differences) between devices, no significant difference was observed for either hand ( $p > 0.05$ ).

### Test–retest reliability

The test–retest reliability of the Camry dynamometer was excellent, with ICC = 0.98 (95% CI: 0.97–0.99) for the dominant hand and ICC = 0.98 (95% CI: 0.97–0.99) for the nondominant hand. The Jamar dynamometer also demonstrated excellent reliability, with ICC = 0.99 (95% CI: 0.98–0.99) for both dominant and nondominant hands (Table 2).

**Table 2.** Reliability and correlations for within-device and between-device grip strength measurement.

Devices	Dominant Hand					Nondominant Hand				
	Test Mean (SD)	Retest Mean (SD)	ICC (95% CI)	Spearman rho <sup>a</sup> p	Z p <sup>‡</sup>	Test Mean (SD)	Retest Mean (SD)	ICC (95% CI)	Spearman rho p	Z p <sup>‡</sup>
JAMAR	31.49 (11.57)	31.26 (11.63)	0.99 (0.98-0.99)	<b>0.956</b> <0.001*	-0.212 0.832	30.02 (11.37)	29.99 (11.68)	0.99 (0.98-0.99)	<b>0.964</b> <0.001*	-0.347 0.729
CAMRY	29.17 (10.57)	28.76 (10.13)	0.98 (0.97-0.99)	<b>0.964</b> <0.001*	-1.287 0.198	27.22 (10.06)	27.50 (10.21)	0.98 (0.97-0.99)	<b>0.957</b> <0.001*	-1.624 0.104
Δ JAMAR			-0.23 (2.66)		-0.444			-0.02 (2.84)		-0.908
Δ CAMRY			-0.41 (2.85)		0.657			0.28 (2.86)		0.364
Spearman rho <sup>b</sup>	<b>0.905</b>	<b>0.918</b>				<b>0.910</b>	<b>0.919</b>			
p	<0.001*	<0.001*				<0.001*	<0.001*			
Z	<b>-5.903</b>	<b>-6.875</b>				<b>-6.319</b>	<b>-6.546</b>			
p <sup>‡</sup>	<0.001*	<0.001*				<0.001*	<0.001*			

SD: Standard Deviation, ICC: Intraclass correlation coefficient, CI: Confidence interval, Spearman rho: Spearman correlation coefficient, a: Within-device test–retest correlation, b: Between-device correlation, ‡: Wilcoxon test, Δ: Test-Retest change score, \* $p < 0.001$ .

### Repeatability

The CV, SEM, MDC, MDC% and LoA% were calculated to assess repeatability, and the

results for both devices and hands are presented in Table 3.

**Table 3.** Repeatability metrics of the Jamar and Camry dynamometers for dominant and nondominant hands.

Devices	Dominant Hand					Nondominant Hand				
	CV%	SEM	MCD	MCD%	95% LoA	CV%	SEM	MCD	MCD%	95% LoA
JAMAR	8.47	1.32	3.67	11.7	-10.46/+5.81	9.46	1.41	3.92	13.0	-11.70/+6.10
CAMRY	9.83	1.46	4.06	14.0		10.45	1.43	3.98	14.5	

CV% – Coefficient of Variation; SEM – Standard Error of Measurement; MDC – Minimal Detectable Change; MDC% – Minimal Detectable Change expressed as a percentage of the mean; 95% LoA – 95% Limits of Agreement between Jamar and Camry measurements.

## Discussion

The findings of the present study demonstrate that the Camry digital hand dynamometer is a valid instrument for assessing handgrip strength in healthy adults. Although a statistically significant difference was observed between the devices in both the initial and retest measurements, no difference was found in the delta (change) values, indicating consistent test–retest performance. Overall, both instruments showed excellent agreement and high repeatability, supporting the use of the Camry as a reliable alternative to the Jamar® hydraulic dynamometer, the current gold standard.

Handgrip strength is a widely accepted indicator of overall muscle strength, physical activity level, and general health, and is frequently used in both healthy and clinical populations for assessment and follow-up.<sup>3</sup> The Jamar dynamometer is the most established tool for handgrip strength measurement due to its well-documented validity and reliability, and numerous studies have examined its performance against other devices.<sup>9,10,28,29</sup> However, direct comparisons with the Camry in healthy populations remain limited.<sup>13,16,30</sup>

Previous research has reported that the Camry dynamometer demonstrates excellent reliability and validity, thereby representing a cost-effective alternative for the assessment of handgrip strength.<sup>13,16</sup> Furthermore, the authors noted that the device exhibits substantial durability and does not necessitate calibration, even following several thousand uses. It should be noted that in this study reliability and validity testing was conducted using known weights rather than human participants.<sup>13</sup>

In a study conducted on 1,064 healthy community-dwelling older adults aged 50–90 years, the CAMRY dynamometer was shown to exhibit excellent reliability and validity.<sup>31</sup>

The authors concluded that it is a reliable, cost-effective, and practical instrument for grip strength assessment in geriatric clinical settings. While our study targeted a different population, the methodology was largely comparable, and the findings were consistent with those reported in that study.

Our results are consistent with previous research<sup>13,16</sup> reporting excellent validity and reliability for the Camry dynamometer, which offers advantages in affordability, portability, and ease of use. Although correlation coefficients between the two devices were very high ( $r > 0.90$ ), Bland–Altman analysis indicated a small but systematic negative bias, with the Camry tending to produce lower values than the Jamar.<sup>16</sup> This difference has been attributed to variations in device mechanism and design: the Jamar uses a hydraulic system, while the Camry is a spring-type digital dynamometer.<sup>32,33</sup> Differences in handle shape, grip span, and ergonomic characteristics may also influence maximal voluntary contraction.<sup>34</sup> These factors likely explain the slightly lower readings observed with the Camry, suggesting that while both devices are valid for group-level analyses, caution is needed when interpreting absolute values for individual assessments.

The absence of significant differences between repeated measurements within each device confirms high internal consistency, while excellent ICC values for both devices ( $ICC \geq 0.98$ ) demonstrate strong test–retest reliability over time. These properties are critical for monitoring changes in grip strength in both clinical and research contexts.<sup>35</sup>

Repeatability analysis showed that the CV values were within the generally accepted range for dynamometry (10–15%), and MDC values were consistent with previously reported thresholds for clinically meaningful change.<sup>36</sup> This indicates that both devices can detect changes in grip strength that are likely to be clinically relevant.

Beyond validity and reliability, device comfort may influence user preference and potentially affect performance in specific patient groups. In the current study, 64.3% of participants reported that the Camry was more comfortable to use, though this preference did not translate into significant differences in measured grip strength. This suggests that perceived comfort does not necessarily enhance maximal voluntary contraction, as grip strength is primarily determined by neuromuscular capacity rather than subjective ergonomics. Nevertheless, higher comfort may improve user compliance and ease of testing, particularly in clinical or elderly populations.<sup>34</sup> Previous reports have noted differences in tactile feedback between the devices, with the Camry's grip piece showing slight displacement during use, which could alter force application in some users.<sup>37</sup> Whether such ergonomic differences affect outcomes in patients with upper limb impairments remains a question for future research.

In summary, the Camry dynamometer represents a valid, practical, and cost-effective alternative to the Jamar for assessing handgrip strength in healthy adults. Its strong concurrent validity, excellent test-retest reliability, and acceptable repeatability metrics support its use in both research and clinical settings, while acknowledging the small systematic bias compared to the Jamar. Further studies in diverse clinical populations are warranted to confirm these findings and to explore whether device comfort or tactile characteristics influence measurement outcomes.

### **Limitations and strengths**

This study has several limitations. First, although participants ranged in age from 18 to 65 years, data were analyzed without classification or stratification into specific age groups. Second, the absence of subgroup analyses by sex may limit the generalizability of the findings, as potential sex-based differences in handgrip strength were not examined. Third, the study included only healthy adults, and the findings may not be directly applicable to clinical populations with upper limb impairments. Fourth, because the researcher performing the measurements was

not blinded, may have resulted in observer bias.

Despite these limitations, present study has notable strengths. To our knowledge, it is the largest sample-size investigation to date examining the reliability and validity of the Camry dynamometer in healthy adults. Furthermore, the use of standardized testing protocols, blinding of participants to measurement results, and comprehensive statistical analyses (including Bland-Altman, ICC, and repeatability metrics) enhance the robustness and reproducibility of the findings.

### **Conclusion**

In conclusion, the Camry dynamometer demonstrated strong concurrent validity, excellent test-retest reliability, and acceptable repeatability for measuring handgrip strength in healthy adults. These findings support its use as a practical and cost-effective alternative to Jamar, particularly in settings where budget limitations restrict access to high-cost devices. Beyond its applicability in healthy populations, the Camry may also be considered for use in clinical groups, provided that potential systematic differences from the Jamar are taken into account when interpreting absolute values. The availability of a valid, reliable, and affordable device for handgrip strength assessment has the potential to expand its adoption in healthcare facilities and research programs with varying financial resources. Future studies should investigate its performance in diverse clinical populations and explore whether device ergonomics or tactile characteristics influence measurement outcomes.

### **Ethics Committee Approval**

This study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Non-Interventional Research Ethics Board at Yalova University in December 2024 (study protocol: 2024/293). This study was registered in ClinicalTrials.gov (NCT06845072). All participants provided written informed consent prior to participating.

## Informed Consent

All participants provided written informed consent prior to participating.

## Author Contributions

Plan, design: PT; Material, methods and data collection: PT, BKK; Data analysis and comments: PT, BKK; Writing and corrections: PT, BKK.

## Conflict of Interest

The authors declared that there is no conflict of interest.

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## Peer-review

Externally peer-reviewed.

## References

- Vaishya R, Misra A, Vaish A, Ursino N, D'Ambrosi R. Hand grip strength as a proposed new vital sign of health: a narrative review of evidences. *J Health Popul Nutr.* 2024;43(1):7. doi:10.1186/s41043-024-00500-y
- Soysal P, Hurst C, Demurtas J, et al. Handgrip strength and health outcomes: Umbrella review of systematic reviews with meta-analyses of observational studies. *J Sport Health Sci.* 2021;10(3):290-295. doi:10.1016/j.jshs.2020.06.009
- Szaflik P, Zadoń H, Michnik R, Nowakowska-Lipiec K. Handgrip Strength as an Indicator of Overall Strength and Functional Performance—Systematic Review. *Applied Sciences.* 2025;15(4):1847. doi:10.3390/app15041847
- Wang YC, Bohannon RW, Li X, Sindhu B, Kapellusch J. Hand-Grip Strength: Normative Reference Values and Equations for Individuals 18 to 85 Years of Age Residing in the United States. *Journal of Orthopaedic & Sports Physical Therapy.* 2018;48(9):685-693. doi:10.2519/jospt.2018.7851
- Du W, Cornett KMD, Donlevy GA, Burns J, McKay MJ. Variability between Different Hand-Held Dynamometers for Measuring Muscle Strength. *Sensors.* 2024;24(6):1861. doi:10.3390/s24061861
- Guerra RS, Amaral TF, Sousa AS, Fonseca I, Pichel F, Restivo MT. Comparison of Jamar and Bodygrip Dynamometers for Handgrip Strength Measurement. *J Strength Cond Res.* 2017;31(7):1931-1940. doi:10.1519/JSC.0000000000001666
- Rolsted SK, Andersen KD, Dandanell G, et al. Comparison of two electronic dynamometers for measuring handgrip strength. *Hand Surg Rehabil.* 2024;43(3):101692. doi:10.1016/j.hansur.2024.101692
- Hogrel JY. Grip strength measured by high precision dynamometry in healthy subjects from 5 to 80 years. *BMC Musculoskelet Disord.* 2015;16(1):139. doi:10.1186/s12891-015-0612-4
- Mathiowetz V. Comparison of Rolyan and Jamar dynamometers for measuring grip strength. *Occup Ther Int.* 2002;9(3):201-209. doi:10.1002/oti.165
- Santos GMX dos, Mauad LD de S, Nardim HCB, et al. Test-retest reliability and concurrent validity of three different handgrip dynamometers (Jamar, Jamar Plus+ and Biodex) in healthy young adults. *Hand Ther.* Published online July 5, 2025. doi:10.1177/17589983251352104
- Roberts HC, Denison HJ, Martin HJ, et al. A review of the measurement of grip strength in clinical and epidemiological studies: towards a standardised approach. *Age Ageing.* 2011;40(4):423-429. doi:10.1093/ageing/afr051
- Svinøy OE, Hilde G, Bergland A, Strand BH. Reference values for Jamar+ digital dynamometer hand grip strength in healthy adults and in adults with non-communicable diseases or osteoarthritis: the Norwegian Tromsø study 2015-2016. *Eur J Ageing.* 2023;20(1):44. doi:10.1007/s10433-023-00791-w
- Sánchez-Aranda L, Fernández-Ortega J, Martín-Fuentes I, et al. Reliability and criterion validity of a low-cost handgrip dynamometer: The Camry. Preprint posted online June 25, 2024. doi:10.1101/2024.06.25.24309304
- Jiménez-Sánchez A, Pereira-Cunill JL, Limón-Mirón ML, López-Ladrón A, Salvador-Bofill FJ, García-Luna PP. A Cross-Sectional Validation Study of Camry EH101 versus JAMAR Plus Handheld Dynamometers in Colorectal Cancer Patients and Their Correlations with Bioelectrical Impedance and Nutritional Status. *Nutrients.* 2024;16(12). doi:10.3390/nu16121824
- Andrade MS, Honorato MP, Vargas JP, de los Angeles Galvez M, Rojas MR. Comparison of two handgrip dynamometers in older adults before elective surgery. *Perioperative Medicine.* 2023;12(1). doi:10.1186/s13741-023-00334-y
- Panhale V, Kini R, Kothale S. Reliability and validity of Camry dynamometer for isometric hand grip strength measurement in healthy Indian adults. *J Hand Microsurg.* 2025;17(4):100291. doi:10.1016/j.jham.2025.100291
- Latorre Román PÁ, López DM, Aguayo BB, Fuentes AR, García-Pinillos F, Redondo MM. Handgrip strength is associated with anthropometrics variables and sex in preschool children: A cross sectional study providing reference values. *Physical Therapy in Sport.* 2017;26:1-6. doi:10.1016/j.ptsp.2017.04.002
- Ekşioglu M. Normative static grip strength of population of Turkey, effects of various factors and a comparison with international norms. *Appl Ergon.* 2016;52:8-17. doi:10.1016/j.apergo.2015.06.023
- Bhat AK, Jindal R, Acharya AM. The influence of ethnic differences based on upper limb anthropometry on grip and pinch strength. *J Clin Orthop Trauma.* 2021;21:101504. doi:10.1016/j.jcot.2021.101504
- Schober P, Boer C, Schwarte LA. Correlation Coefficients: Appropriate Use and Interpretation. *Anesth Analg.* 2018;126(5):1763-1768. doi:10.1213/ANE.0000000000002864
- Bonett DG, Wright TA. Sample Size Requirements for Estimating Pearson, Kendall and Spearman Correlations. *Psychometrika.* 2000;65(1):23-28. doi:10.1007/BF02294183
- Bhat AK, Jindal R, Acharya AM. The influence of ethnic differences based on upper limb anthropometry on grip and pinch strength. *J Clin Orthop Trauma.* 2021;21:101504. doi:10.1016/j.jcot.2021.101504
- Núñez-Cortés R, Cruz B del P, Gallardo-Gómez D, et al. Handgrip strength measurement protocols for all-cause and cause-specific mortality outcomes in more than 3 million participants: A systematic review and meta-regression analysis. *Clinical Nutrition.* 2022;41(11):2473-2489. doi:10.1016/j.clnu.2022.09.006
- Cohen J. *Statistical Power Analysis for the Behavioral Sciences.* Routledge.; 2013.
- Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet.* 1986;1(8476):307-310.
- Koo TK, Li MY. A Guideline of Selecting and Reporting Intraclass Correlation Coefficients for Reliability Research. *J Chiropr Med.* 2016;15(2):155-163. doi:10.1016/j.jcm.2016.02.012
- Portney LG. Foundations of clinical research: applications to evidence-based practice. FA Davis. In: 2020.
- Cildan Uysal S, Tonak HA, Kitis A. Validity, reliability and test-retest study of Grip strength measurement in two positions with two dynamometers: Jamar® Plus and K-Force® Grip. *Hand Surg Rehabil.* 2022;41(3):305-310. doi:10.1016/j.hansur.2022.02.007
- Guerra RS, Amaral TF, Sousa AS, Fonseca I, Pichel F, Restivo MT. Comparison of Jamar and Bodygrip Dynamometers for Handgrip Strength Measurement. *J Strength Cond Res.* 2017;31(7):1931-1940. doi:10.1519/JSC.0000000000001666
- Gorgu S, Yilmaz M, Atilgan E. Reliability of the use of Camry versus Jamar dynamometer. *Medicine Science | International Medical Journal.* 2025;14(2):442. doi:10.5455/medscience.2025.01.027

31. Huang L, Liu Y, Lin T, et al. Reliability and validity of two hand dynamometers when used by community-dwelling adults aged over 50 years. *BMC Geriatr.* 2022;22(1). doi:10.1186/s12877-022-03270-6
32. Roberts HC, Denison HJ, Martin HJ, et al. A review of the measurement of grip strength in clinical and epidemiological studies: towards a standardised approach. *Age Ageing.* 2011;40(4):423-429. doi:10.1093/ageing/afr051
33. Díaz Muñoz GA, Calvera Millán SJ. Comparing the Camry dynamometer to the Jamar dynamometer for use in healthy Colombian adults. *Revista Salud Bosque.* 2019;9(2):21-29. doi:10.18270/rsb.v9i2.2794
34. Lupton-Smith A, Fourie K, Mazinyo A, Mokone M, Nxaba S, Morrow B. Measurement of hand grip strength: A cross-sectional study of two dynamometry devices. *South African Journal of Physiotherapy.* 2022;78(1). doi:10.4102/sajp.v78i1.1768
35. Kamper SJ. Reliability and Validity: Linking Evidence to Practice. *Journal of Orthopaedic & Sports Physical Therapy.* 2019;49(4):286-287. doi:10.2519/jospt.2019.0702
36. Conforto I, Samir C, Chausse F, Goldstein A, Pereira B, Coudeyre E. Comparison of psychometric properties between the Labin, a new electronic dynamometer, and the Jamar: Preliminary results in healthy subjects. *Hand Surg Rehabil.* 2019;38(5):293-297. doi:10.1016/j.hansur.2019.07.009
37. Lupton-Smith A, Fourie K, Mazinyo A, Mokone M, Nxaba S, Morrow B. Measurement of hand grip strength: A cross-sectional study of two dynamometry devices. *South African Journal of Physiotherapy.* 2022;78(1). doi:10.4102/sajp.v78i1.1768