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ORIGINAL ARTICLE

Investigation of the Validity and Reliability of the K-Force® Grip Dynamometer in the Evaluation of Hand Grip Strength in Individuals with Carpal Tunnel Syndrome

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ABSTRAK

Penurunan kekuatan genggaman merupakan salah satu gejala yang paling biasa dalam sindrom terowong karpal (CTS). Kekuatan genggaman diketahui mempunyai kaitan rapat dengan kualiti hidup dan fungsi anggota atas. Sehubungan itu, kajian ini bertujuan untuk menilai kesahihan dan kebolehpercayaan K-Force® Grip Dynamometer (KFGD), yang digunakan untuk menilai kekuatan genggaman tangan dalam kalangan individu dengan CTS. Seramai 35 orang sukarelawan dengan CTS unilateral berumur antara 35-63 tahun telah mengambil bahagian dalam kajian ini. Dua orang penilai telah menilai kekuatan genggaman peserta sebanyak dua kali setiap seorang, menjadikan jumlah keseluruhan empat kali penilaian menggunakan KFGD. Selain itu, kekuatan genggaman juga dinilai sekali menggunakan Baseline® Grip Dynamometer. Berdasarkan hasil kajian, kebolehpercayaan antara penilai (inter-rater) dan ulangan ujian (test-retest) dalam penilaian kekuatan genggaman menggunakan KFGD adalah sangat baik (ICC>0.80). Tambahan pula, terdapat korelasi yang tinggi antara nilai kekuatan genggaman yang diperoleh melalui KFGD dan Baseline® Grip Dynamometer (r>0.80, p<0.05). Oleh itu, KFGD boleh dianggap sebagai alat yang sah, boleh dipercayai dan praktikal untuk menilai kekuatan genggaman tangan.
Kata kunci: *Dinamometer; kekuatan genggaman tangan; sindrom terowong karpal*

ABSTRACT

Decreased grip strength is one of the most common symptoms of carpal tunnel syndrome (CTS). Grip strength is well-known to be closely related to quality of life and upper extremity functionality. In this context, the aim of our study was to examine the validity and reliability of the K-Force® Grip dynamometer (KFGD), which evaluated hand grip strength in individuals with CTS. A total of

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35 unilateral CTS volunteers, aged 35-63 years were included in this study. Each of the two raters evaluated the participants' grip strength twice, for a total of four times, using the KFGD. In addition, grip strength was evaluated once with a Baseline® Grip dynamometer. According to the study findings, both inter-rater and test-retest reliability in the grip strength assessment of the KFGD were excellent (ICC>0.80). In addition, a high correlation was found between the grip strength values of the KFGD and the grip strength values of the Baseline® Grip dynamometer ($r>0.80$, $p<0.05$). The KFGD can be considered a valid, reliable and practical device for evaluating grip strength.
Keywords: Carpal tunnel syndrome; dynamometers; hand grip strength

INTRODUCTION

Carpal tunnel syndrome (CTS) is weakness, pain, numbness and tingling in the hand and fingers caused by squeezing the median nerve as it passes along the carpal tunnel (De et al. 2013; Keith et al. 2009). In CTS, there is a loss of upper extremity functionality with a decrease in grip strength (Nazari et al. 2017). Grip strength is accepted as a predictor of the physical and functional condition of the upper extremity, surgical success and return to work (Appleby et al. 2009; Bae et al. 2018). Moreover, studies have shown that grip strength is linked to quality of life in patients with CTS (Núñez-Cortés et al. 2020).

The K-Force® Grip dynamometer (KFGD) Kinvent™ (Montpellier, France) is an isometric dynamometer developed by biomedical engineers to evaluate hand grip strength. The device weighs 200 g, measures 141 x 47 x 61 mm, and evaluates grip strength up to 90 kg. It can connect wirelessly up to ten meters away, and data obtained from the device can be transferred to smartphones and computers via Bluetooth® connections (Uysal et al. 2022).

As it is known, in order for a device to be used in clinical environments and academic studies, it is necessary to carry out the validity and reliability of the device. This study aimed to assess the validity and reliability of the KFGD for measuring grip strength in individuals with CTS.

MATERIALS AND METHODS

Patients aged 35-63 years with unilateral, moderate, and mild CTS diagnosed by neurologists were included in the study. The ethics committee approval of the study was approved by the ethics committee of Kır ehir Ahi Evran University (Number: 2022-22/193). In the sample size calculation of the study, it was stated in the literature that reliability and validity studies in rehabilitation measurements should consist of 30-50 participants.

Participants

Inclusion criteria for the study were: (i) individuals who were older than 18 years of age; (ii) volunteered; (iii) had a medical diagnosis of unilateral CTS; and (iv) had symptoms of CTS for more than one year were included. Exclusion criteria were inability to understand instructions and another neuromuscular disorder of the upper limb.

Study Design

Hand grip strength were evaluated with both the KFGD (Kinvent, Montpellier, France) and Baseline® Grip dynamometer (Baseline Corporation, NY, USA). To examine the construct validity of KFGD, its relationship with Baseline® Grip dynamometer values were examined. In addition, KFGD evaluations for

both inter-rater and test-retest reliability of KFGD were repeated by two physiotherapists (MC, K).

Before starting the evaluation, the protocol was explained to the individuals, and the device was introduced. Evaluations were made in a quiet room so that participants would not be distracted. Two trial assessments were performed first, followed by three assessments with 5 seconds rest periods. (Since there is no standard time and repetition in the instructions for use of the device or in the literature, these times and repetitions were determined in line with the consensus of the authors)

Evaluation of Hand Grip Strength

(i) Baseline® Grip Dynamometer

The grip strength of the participants was evaluated with the Baseline® Grip isometric dynamometer. Measurements were taken with the participants seated, their shoulders at 0 abduction, elbows at 90 flexion, and wrists in a neutral position (Figure 1). Participants were asked to squeeze the dynamometer 3 times with 5-second rest periods. The best score was recorded in kg. Then, after a rest period of 10 minutes, KFGD measurements were started.

(ii) K-Force® Grip Dynamometer

The participants' positioning was the same as in the Baseline® Grip dynamometer evaluations. In this position, the participants were asked to squeeze the KFGD (Figure 1). The assessment was started by pressing the "start" button on the mobile device. The device recorded the grip strength values. Participants were asked to squeeze the device three times, and two physiotherapists repeated this assessment separately. There was a five-second rest between measurements. To examine the test-retest reliability of the device, both physiotherapists repeated the measurement after approximately 10 minutes. The best score obtained on the device was recorded in kilograms.

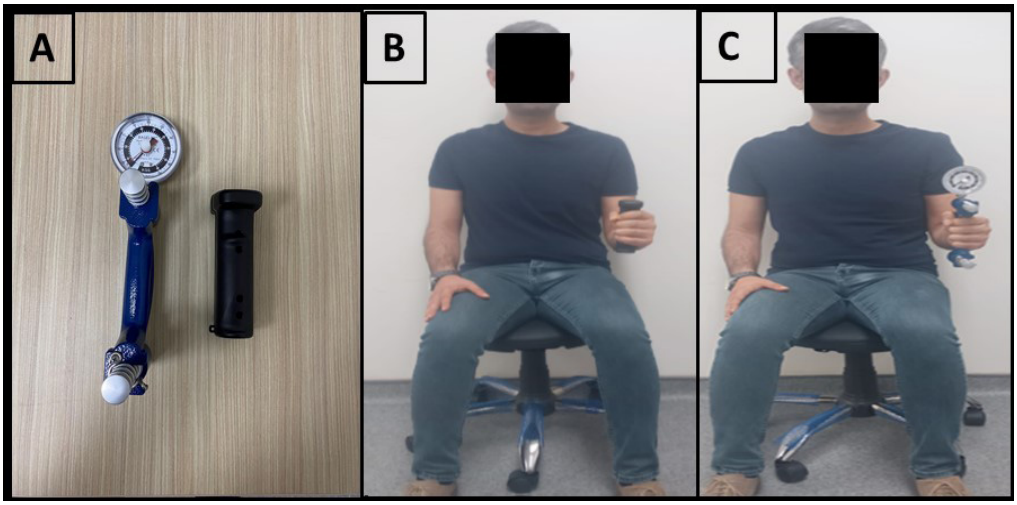

FIGURE 1: (A) K-Force® Grip dynamometer and Baseline® Grip dynamometer; (B) Grip strength; (C) Grip strength assessment with the Baseline® Grip dynamometer

Statistical Analysis

All statistical analyses were performed using SPSS version 24 software (SPSS Inc, Chicago, Illinois). A combination of visual methods and analytical techniques was used to assess the normal distribution of the variables. The reliability of the KFGD was evaluated using the intraclass correlation coefficient (ICC). ICC values were classified as follows: poor (<0.40), fair (0.40-0.59), good (0.60-0.79), and excellent (>0.80) reliability (Koo & Li 2016). To determine the concurrent validity of the KFGD based on its relationship with secondary measurements, a Pearson correlation analysis was conducted. Correlation coefficients were classified as poor (<0.30), moderate (0.30-0.60) and strong (>0.60) (Schober et al. 2018). The standard error of measurement (SEM) for the KFGD scores was calculated using the formula: SEM = Standard deviation x (1 - ICC). To determine the minimal detectable change at a 95% confidence interval (MDC_{95}), the following formula was used: MDC_{95} = 1.96 x SEM x 2 (Portney & Watkins 2009). Statistical significance was set at $p<0.05$.

RESULTS

Detailed demographic information for the individuals with CTS included in the study was provided in Table 1.

The mean clinical measurements were shown in Table 2. The first rater's test-retest ICC values for KFGD were 0.98. This result showed us that the individuals included in the study had excellent test-retest validity in the hand grip strength evaluation of the KFGD.

When we looked at the inter-rater reliability of KFGD between the first and second raters for hand grip strength, the ICC values were 0.99. Thus, the inter-rater reliability of the KFGD was also found to be excellent (Table 3).

In order to determine the concurrent validity of hand grip strength in individuals with CTS included in the study, the correlation results of KFGD with the Baseline® Grip dynamometer, which is frequently used in the clinic, were analysed in Table 4. According to these results, there was a highly significant correlation between KFGD hand grip strength and Baseline® Grip dynamometer hand grip strength values ($r= 0.976$, $p<0.001$).

TABLE 1: Participants' demographics features

		(n=35)			
		Mean	**SD**	**Minimum**	**Maximum**
Age (years)		51.40	6.95	35.00	63.00
Height (cm)		163.69	6.31	150.00	176.00
Weight (kg)		74.86	14.77	49.00	120.00
BMI (kg/m^2)		28.16	6.31	17.17	41.52
		n		**(%)**	
Gender	Male	9		25.7	
	Female	26		74.3	
Injured side	Right	23		65.7	
	Left	12		34.3	
Dominant side	Right	16		45.7	
	Left	19		54.3	

SD: Standard deviation; BMI: Body mass index

TABLE 2: The mean values of the measurements of the hand grip strength

		(n=35)		Minimum	Maximum
		Mean	SD		
Baseline® Grip dynamometer (kg)		20.94	4.62	12	34
K-Force® Grip dynamometer (First rater, kg)	Test	18.23	4.72	8	31
	Retest	17.66	4.33	9	30
K-Force® Grip dynamometer (Second rater, kg)	Test	18.01	4.53	8.5	30.5
	Retest	17.91	4.18	10	29

SD: Standard deviation

TABLE 3: Inter-rater (ICC) and test-retest (ICC) reliability of the K-Force® Grip dynamometer

n=35	Difference (Mean SD)	Inter-rater (ICC 1,2) (95% CI)	Test-retest (ICC 1,1) (95% CI)	SEM_{95}	MDC_{95}
K-Force® Grip dynamometer	-0.57 ± 0.80	0.99 (0.98-0.99)	0.98 (0.97-0.99)	0.11	0.29

SD: Standard deviation; ICC: Intraclass correlation coefficient; SEM: Standard error of measurement; MDC95: Minimum detectable change at the 95% confidence interval

TABLE 4: Relationship between K-Force® Grip dynamometer and Baseline® Grip dynamometer hand grip strength evaluations

		K-Force® Grip dynamometer (kg)
Baseline® Grip dynamometer (kg)	r	0.976
	p	<0.001

r: Pearson correlation coefficient; $p < 0.05$

DISCUSSION

Based on the results of the current study, the test-retest reliability of the KFGD in individuals with CTS was excellent. We also proved it is valid in the assessment of grip strength due to the important relationship between the KFGD and the Baseline® Grip dynamometer. Also, in this study, we present for the first time the MDC_{95} and SEM_{95} values of the KFGD dynamometer for the assessment of grip strength in individuals with CTS.

When the literature is examined, it is seen that many practical and reliable hand grip dynamometers have been developed. In this study, we investigated the reliability of the KFGD, which is a portable device that transmits data to smartphones and computers via Bluetooth® connections, on hand grip strength. Uysal et al. (2022) examined the test-retest reliability of the KFGD in healthy subjects in two different positions and concluded that the test-retest reliability was excellent (ICC= 0.97-0.98). Also, Nikodelis et al. (2021) examined the validity and reliability of the KFGD in healthy subjects and individuals with shoulder impingement syndrome. The test-retest reliability of the KFGD was excellent in both healthy individuals and individuals with shoulder impingement syndrome (ICC=0.96, ICC=0.97, respectively). Magni et al. (2023)

concluded that the reliability of both the KFGD and the Jamar hand dynamometer in healthy subjects was excellent. In another study, Hamilton et al. (1992) stated that the reliability of the Jamar hand dynamometer, which is most frequently used in clinical settings, is excellent (ICC=0.82). In the present study, both the test-retest and inter-rater reliability of the KFGD were found to be excellent (ICC=0.98, ICC=0.99, respectively).

In order for a device to be used in clinical and rehabilitation applications, it must be validated. Scholtes et al. (2011) recommended that validity studies should utilise correlation coefficients and highlighted that the correlation coefficient should be greater than 0.70. In the literature, Uysal et al. (2022) concluded that there is a strong relationship between the KFGD and the Jamar hand dynamometer. In addition, Magni et al. (2023) reported a strong correlation between the KFGD and the Jamar hand dynamometer in healthy subjects ($r \geq 0.89$)). In this study, we used a Baseline® Grip dynamometer for the concurrent validity of the KFGD. This study is in line with the literature, and we found a strong correlation between the KFGD and the Baseline® Grip dynamometer ($r=0.976$, $p<0.001$). In line with these results, it can be concluded that the KFGD is a valid device for evaluating grip strength.

One of the key findings of this study is that the KFGD provides lower values than the Baseline® Grip Dynamometer, despite measuring in the same manner. In other studies, it was observed that the grip force value of the KFGD is lower than that of the other dynamometers (Magni et al. 2023; Uysal et al. 2022). We think that this difference may be due to the different weights of the devices (Baseline® Grip: 1300 g; K-Force® Grip: 200 g) or the difference between the grip areas. In addition, due to the different shapes of the devices, different forces may be released. On the KFGD, patients created force with a cylindrical grip, while on the Baseline® Grip dynamometer, they created force with a hook grip.

The MDC_{95} indicates the smallest difference required to confirm a genuine change in the patient's health status, whereas the SEM_{95} reflects the possible measurement error that might arise (Revicki et al. 2008). In the present study, we found the SEM_{95} value of the KFGD to be 0.11. While Uysal et al. (2022) did not examine the SEM_{95} value of the KFGD, Magini et al. (2023) stated that the SEM_{95} value of the KFGD ranged from 1.7 to 2. In this study, we found the MDC_{95} value of the KFGD to be 0.29. The MDC_{95} value of the KFGD was determined by Magni et al. (2023) in the range of 4.7-5.7, Uysal et al. (2022), on the other hand, found it was in the range of 0.7-0.9 in standing and sitting positions.

Study Limitation

The primary limitation of this study is the lack of a control group that includes healthy subjects. In future studies, there is a need for studies examining the validity and reliability of the KFGD in different upper extremity pathologies, including the healthy control group.

CONCLUSION

Test-retest and inter-rater reliability are excellent in assessing grip strength with the KFGD and have strong concurrent validity with the Baseline® Grip dynamometer. The KFGD is an easy-to-use and reliable device.

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Writing: Ş.K., F.T.

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