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Validity and Reliability Of Isometric Muscle Strength Using The Powrlink Portable Device

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ABSTRACT

Background: A muscle strength testing device that is convenient, practical, reliable, and valid is essential in clinical and field settings. **Objective:** Therefore, the purpose of this study was to determine the validity and reliability of measuring isometric muscle strength with the Powrlink handheld dynamometer compared to an established force dynamometer. **Method:** Sixty-one university students (40 males and 21 females) completed two standardized testing sessions seven days apart. Each session consisted of a familiarization period followed by three peak isometric muscle strength tests. Intraclass correlation (ICC, model: two-way mixture with absolute agreement), standard error of measurement (SEM), minimum detectable change (MDC), and 95% limits of agreement (LOA) for intra- and inter-rater reliability were determined. Results: Test-retest reliability (ICC > 0.91) and intertrial reliability (ICC > 0.99) were excellent. No significant differences were observed in peak and mean knee forces and torques between the test and retest, indicating high test-retest reliability. **Conclusion:** The Powrlink device is portable, convenient, responsive, and cost-effective, has excellent test-retest reliability, and can be used to measure maximal isometric force in the clinic and in the field.

Keywords: Handheld dynamometry, Portable dynamometer anchoring system, Powrlink, Muscle Strength, Validity

INTRODUCTION

Physical fitness measurements are widely used in medicine and sports science, providing controlled and scientific measures of physical performance (Shahidi, Kingsley, Svensson, TAŞKIRAN, & Hassani, 2021). Different dimensions are available depending on the purpose and intended use (Austin, Brown, Nicholson, & Clark, 2022). In physical assessment, maximal isometric strength is used as an objective parameter to prescribe exercises (Cvečka et al., 2022). Force measurement can provide important information about how decreased force affects functional limitations in daily activities (Katoh, 2022). The maximum strength capacity of a muscle or muscle group indicates a person's physical capacity (Katoh & Yamasaki, 2009b). On the other hand, muscle weakness indicates adverse health effects, including bone health, the risk for cardiometabolic disease, physical dysfunction, all-cause mortality, and sarcopenia (Katoh & Yamasaki, 2009a). Therefore, objective assessment of muscle strength in clinical and athletic populations is critical to track specific changes in muscle and joint movements. These include electromyography, hand dynamometry (HHD), and isokinetic dynamometry (Kozinc, Smajla, Trajković, & Šarabon, 2022). Isokinetic dynamometry is the criterion for evaluating muscle strength, but it is expensive, not portable, requires extensive training of personnel and is limited to the laboratory setting (Lu et al., 2011). HHD may be a viable option for coaches and clinicians to assess muscle strength (Najiah et al., 2021). Recent evidence suggests that HHD is a valid and reliable method for assessing trunk flexion in young athletes who are typically familiar with performing strength measurements as part of routine training and monitoring, which is critical for determining the intensity of strength training and evaluating the effectiveness of a rehabilitation program (Oktavian & Sugiyanto). However, the measuring instrument must be inexpensive, time-saving, portable, and easy for daily clinical practice (Guex, Daucourt, & Borloz, 2015; Hébert et al., 2011). If valid and reliable, inexpensive and portable devices may be a suitable and convenient method for assessing muscle strength in the clinical setting compared with expensive laboratory dynamometers. In their systematic review, Stark et al. (2011) compared the Biodex isokinetic dynamometer as the gold standard device with the HDD, highlighting the HDD's ease of use, portability, cost, and compact size. Compared to isokinetic devices, the HDD is a reliable and valid tool for assessing muscle strength in a clinical setting (Stark, Walker, Phillips, Fejer, & Beck, 2011). Therefore, the current study aims to a) confirm the validity of the Powrlink device and b) evaluate its test-retest reliability.

METHODS

Participants

Sixty-one healthy students from Istanbul Gedik University participated in this study. Demographic characteristics are shown in Table 1. Participants with muscle injuries, cardiovascular symptoms, and neuromuscular or systemic diseases were excluded. Each participant's height, weight, and date of birth were recorded before testing. Participants were asked to refrain from intense physical activity 24 hours before the test. Written informed consent was obtained before participation. Ethical approval was obtained from the Ethics Committee of Istanbul Gedik University, Istanbul, Turkey.

Experimental Design

A single experienced researcher consistently examined the participants during three separate visits to the laboratory, which were spaced seven days apart, and the testing was conducted at the same time of day for each visit.. During the initial visit of research studies, participants undergo anthropometric measurements while adhering to standardized protocols, which typically include the requirement of wearing minimal clothing such as shorts and a T-shirt.An electronic scale was used to measure and a portable stadiometer (SECA, Leicester, UK) was used to measure height. At the second and third visits, maximal voluntary isometric strength (in kilograms [kg]) was measured simultaneously with a digital leg dynamometer Takei (Takei Instruments Ltd 5402, Tokyo, Japan) and Powrlink force dynamometer (Aerobis, Cologne, Germany). A repeated-measures protocol was employed to assess the test-retest reliability of the measurements in the third section.. Prior to familiarization and testing, all participants performed a standardized warm-up protocol consisting of ten minutes of low-intensity aerobic and dynamic muscle stretching exercises.

Isometric Muscle Strength Testing

The Takei portable dynamometer (standard) (Coldwells, Atkinson, & Reilly, 1994) and Powrlink were used simultaneously to assess leg-back muscle strength, with results recorded in kg. During dynamometry, participants placed their feet on the dynamometer and held their arms to the side of their bodies, apartment on their backs and slightly forward. They were then asked to pull the dynamometer bar with their hands at maximum speed, using only their legs and not their backs, until their knees were fully extended, which took no more than 3 seconds as previously has described (Coldwells et al., 1994). If pain occurred during any of the assessments, the test was terminated. Three trials were measured using the Takei portable dynamometer and Powrlink sensor meter, with a two-minute break between each trial. Maximal muscle strenght (in kilograms) was measured on each trial (Figure 1). The set-up and verbal instructions remained the same for all three trials.

Statistical Analyses

The analysis was performed using SPSS version 25 and Microsoft Excel. The significance level was set at $p < 0.05$ for all tests. For statistical analysis, the maximum value was considered in each test with three trials. The normality distribution of the data was examined and confirmed using the Shapiro-Wilk test. The first step of the analysis was to calculate the interrater and intrarater reliability, expressed as the degree of agreement in an intraclass correlation coefficient (ICC). ICC data were calculated using the following parameters: (1) model: two-way random effects; (2) type: average raters; and (3) definition: consistency. An ICC with a value greater than 0.90

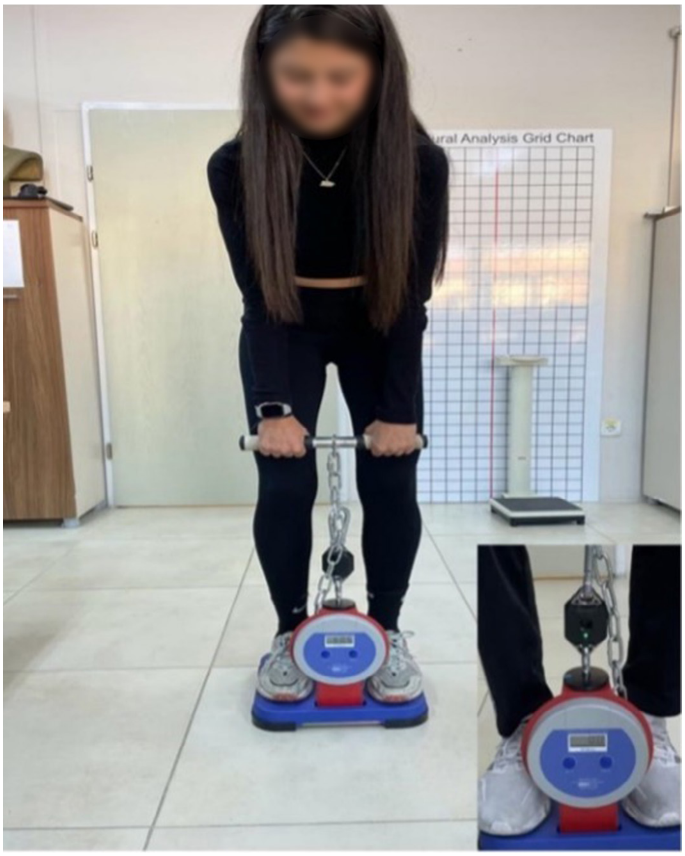

Figure 1. Display of the experimental setup, simultaneously using the Takei and the Powrlink force dynamometers for assessing leg-back muscle strength.

was considered excellent and an ICC with a value between 0.75 and 0.90 was considered good with 95% confidence interval (CI). Correlations between the Takei and Powrlink strength measurements were calculated using Pearson correlation estimates. The reliability of the Powrlink ICCs was estimated along with 95% confidence intervals. In addition, the linear regression coefficient (r2) was calculated to determine whether variation in the results of the tested instrument (Powrlink) could be explained by variation in the gold standard (isometric leg dynamometer). The standard error of measurement (SEM) and minimum detectable change (MDC) with 95% confidence interval was calculated by dividing the SD of the mean differences between the 2 measurements by the square root of 2 (SEM = SD × √ 1 - ICC). SEM % was defined as (SEM /X) x 100, where X is the mean for all observations from test sessions 1 and 2. MDC was calculated using the following formula MDC = Z × SEM × √ 2, where z = 1.96 (based on 95% confidence), indicating the smallest observable change that is real and not due to measurement error in the measurement. To calculate MDC independent of the units of measurement, MDC% was defined as (MDC/X) x 100A smaller MDC indicates a more sensitive measurement.

RESULTS

61 participants were studied (male; n = 41; female: n = 20). Data on age, weight, height, body mass index, dynamometer, and Powrlink mean±SD of the group are shown in Table 1.

Table 1. Descriptive statistics (mean ± SD)

Variables	Mean ± SD		
	Males (n=41)	**Females (n=20)**	**Total (n=61)**
Age (y)	22.6 ± 4.3	20.8 ± 2.1	22 ± 3.8
Weight (kg)	78 ± 10.7	58 ± 7.4	71.7 ± 13.3
Height (cm)	176. 7 ± 6.4	164.3 ± 7.1	172.6 ± 8.9
BMI (kg/ m^2)	24.9 ± 3.1	21.7 ± 2	23.9 ± 3.2
Dynamometer (kg)	139.2 ± 31.8	79.4 ± 17	119.6 ± 39.5
Powrlink (kg)	139.4 ± 29.7	82.1 ± 17.3	120.6 ± 37.7

Note. Excellent correlation was observed between the isometric leg dynamometer and Powrlink measurements (ICC=0.99, see Table 2).

Table 2. Intra- and inter-rater reliability of maximal isometric strength testing measures obtained with the Takei and the Powrlink force dynamometers.

Variables	Minimum	Maximum	Mean	Std. E	SD	N
Test	42.2	185.8	112.282	4.7075	36.7670	61
Retest	49.4	189.2	117.797	4.8936	38.2203	61
Daynamometer	46.0	198.2	119.626	5.0693	39.5923	61
Powrlink	50.2	189.2	120.641	4.8271	37.7009	61
ICC	95% CI		F Test with True Value 0			*P*
	Lower Bound	Upper Bound	Value	df1	df2	
Test-Retest	0.939	0.985	43.054	60	60	0.001
Test-Retest (males)	0.93	0.98	26.623	40	40	0.001
Test-Retest (fe-males)	0.845	0.976	16.316	19	19	0.001
Daynamometer - Powrlink	0.996	0.999	443.251	60	60	0.001

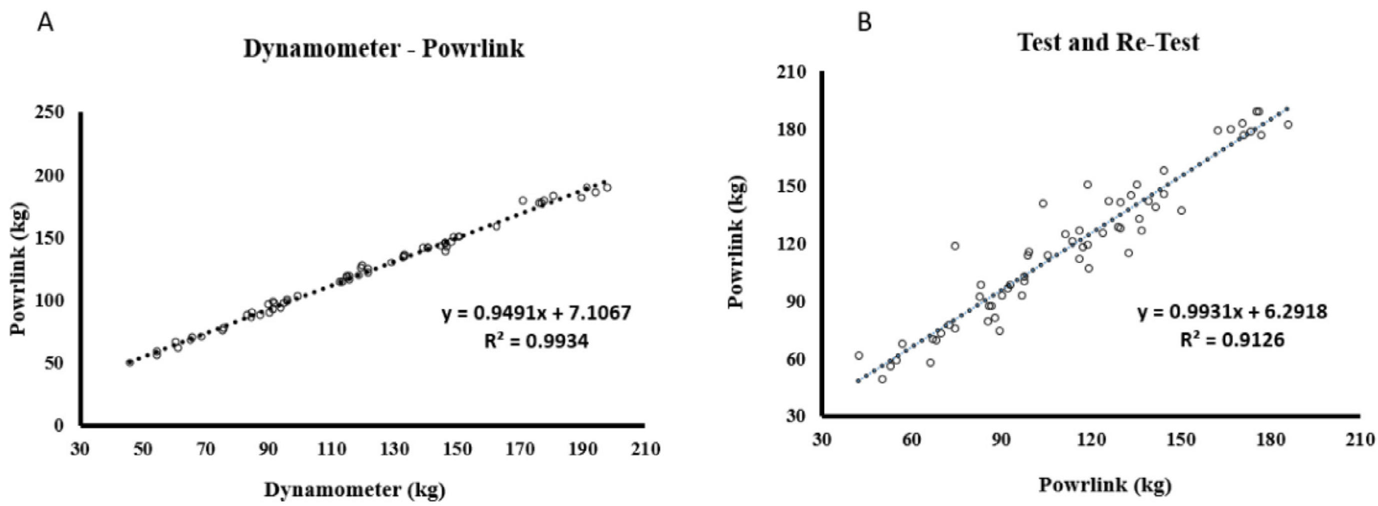

Figure 2.

Note. Panel A; Pearson correlation coefficient between measures obtained with the Takei and the Powrlink force dynamometers. Panel B; Pearson correlation coefficient between the test and retest measures of the Powrlink force dynamometer.

The correlation between the dynamometer and the Powrlink was high (r= 0.99, $p < 0.00$; Figure 2). The Pearson correlation assessing the test-retest reliability of the Powrlink indicated excellent reliability (Figure 2) and showed a high (r= 0.95, $p < 0.001$) correlation between test and retest (Figure 2).

In addition, the correlation between genders for Powrlink test-retest reliability was high (male, r = 0.96, $p < 0.001$; female, r = 0.93, $p < 0.001$). The SEM and % SEM were 6.4 points and 5.4%, respectively. The MDC95 and %MDC95 of Powrlink were 17.8 points and 15.1%, respectively. A change of at least 6.4 points indicates a true change in the measured construct with a 95% confidence level. Thus, if the changes in the outcome exceed the MDC, the probability that no true change occurred is less than 5%.

DISCUSSION

To date, there is a paucity of research examining the validity and reliability of the isometric leg strength test utilizing the Powrlink device. In this study, we investigated the test-retest reliability of Powrlink and its validity compared with the isometric strength dynamometer method. We found that the Powrlink device is reliable for the assessment of isometric leg strength, as indicated by the high ICC for the entire sample. Acceptable sensitivity was demonstrated, with the values obtained indicating low SEM. High validity and reliability were observed when the powrlink was simultaneously fixed with a dynamometer. We analyzed reliability using a reliability scale that defined excellent reliability as .75 and above, moderate to good reliability as .40 to .75, and poor reliability as less than .40. Based on these reference values, our calculated values for both intrarater reliability (0.99) and interrater reliability (0.99) were excellent for all techniques. These results are similar to the results of other HHD fixation studies that demonstrated substantial intra- and inter-rater reliability when evaluating maximal isometric knee extensor strength measurements. These findings underscore the system's high degree of measurement consistency and agreement, supporting its reliability in accurately assessing knee extensor strength.(Katoh, 2022; Katoh & Yamasaki, 2009a, 2009b; Kozinc et al., 2022; Lu et al., 2011). Evaluating strength in the laboratory and in the field is essential to assess and monitor progress and guide training. An essential aspect of any power measurement equipment is the ability to reproduce results under the same test conditions so that any observed changes can be attributed to training progress (Sung, Yi, & Shin, 2019). The results of the current study show that the Powrlink portable device produced similar results for all three trials for both samples examined in the study, as there was no bias in any of the above assessments. Limitations of the current study include that we only examined the validity and reliability of the device during isometric leg strength testing. It should also be noted that the Powrlink portable device has a force limit of 0 to 198 kg. Therefore, we excluded force production greater than 200 kg. Future studies should examine different populations with different muscle groups and angles

In conclusion, the simple, portable, and inexpensive method used in this study to measure isometric force has high validity and reliability. The Powrlink device is a simple evaluation tool that can be used in training and clinical settings to measure isometric muscle strength in adult males and females and is a reliable strength testing device for testing and monitoring strength training. Both tests were found to have high reliability and acceptable sensitivity, making the force gage sufficiently sensitive to detect small changes.

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AUTHORS' CONTRIBUTIONS

S.H.S and I.Ö: contributed to the study concept, design, and study supervision. S.H.S, I.Ö, and S.K: were involved in the acquisition of data, analysis and interpretation of data, and critical revision of the manuscript. S.H.S, S.K, and J.E: participated in the writing and revision of the manuscript. S.H.S, M.Y.T, and S.K: provided assistance with funding.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AVAILABILITY OF DATA AND MATERIALS

The data set is available upon reasonable request from the corresponding author.

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