Comparison of a Hand-Held and Fixed Dynamometer in Measuring Strength of Patients With Neuromuscular Disease

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While numerous studies report acceptable reliability of hand-held dynamometers, very little information is available on factors affecting measurements and comparisons with other force measurement systems. A hand-held dynamometer was compared to a fixed dynamometer to determine if the two systems of force measurement yielded comparable results. Twenty-one patients with neuromuscular disease were measured for maximal isometric strength of 12 muscle groups with both force measurement systems using standardized positioning and stabilization procedures. Only one of the 12 muscle groups tested demonstrated significantly different force measurements between the two systems. Good association was found between both systems in force measurements, with Pearson correlation coefficients ranging from .76 to .90. We conclude that a hand-held dynamometer and a fixed dynamometer yield comparable results in patients with neuromuscular disease, provided that testing is limited to muscle groups producing relatively low forces.

Key Words: *muscle strength, neuromuscular disease, methods*

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Hand-held dynamometers (HHDs) are gaining widespread usage in clinical and research settings for measuring maximal isometric muscle strength (13,16,18,19,29,36). They are easy to use in a clinical setting and have demonstrated acceptable intertester and intratester reliability (1,6–11,12,21,26,31–35).

Numerous authors, however, have questioned the ability of HHDs to accurately measure strength, especially at high force levels (1,12,16, 17,20,21,23,24,28,31,33–35). When using a HHD to measure high muscle forces, the strength of the tester may limit test results because the tester is required to match the strength of the subject for "make" contractions or to overcome the strength of the subject in "break" contractions (30). The tester may also encounter difficulty in attempting to stabilize both the HHD and the patient during the test. The purpose of this study was to determine if differences existed between force measurements obtained with a HHD and a fixed dynamometer (FD) when measuring muscle groups producing relatively low forces in patients with neuromuscular disease. This type of comparison is defined by the Task Force on Standards for Measurements in Physical Therapy as parallel-forms reliability: "the consistency or agreement of measurements obtained with different (alternate) forms of a test; indicates whether measurements obtained with different forms of a test can be used interchangeably" (27). If no differences exist between the two force measurement systems, additional justification would be given for the use of HHDs in force measurements at relatively low force levels.

METHOD

Patients

Twenty-one patients with neuromuscular disease, all demonstrating some extremity weakness on clinical exam, were recruited from a neuromuscular clinic and volunteered to participate in the study (Table 1). No patient had any cognitive, orthopaedic, pain-related, or other disorder that might hinder them from performing a maximal strength test. Each subject signed an institutionally approved informed consent form.

Instrumentation

The FD system (Figure 1) included an Interface SM-250 electronic strain gauge (Interface, Inc., Scottsdale, AZ). The strain gauge was attached to orthopaedics bars, which were in turn attached to a standard treatment table and a Linseis LM 24 strip chart recorder (Linseis, Inc. Princeton Junction, NJ). Measurements were recorded to the nearest kg. This system has been used for 2 years by the author, who has demonstrated intratester reliability of 1.28% variability between measurements obtained at two different times. Construct validity of

Diagnosis	N	Men	Women	$\bar{X}$ Age
Amyotrophic lateral sclerosis	7	5	2	51
Myositis	4	1	3	57
Charcot-Marie-Tooth	1		1	53
Myotonic dystrophy	1		1	49
Limb-girdle dystrophy	3	2	1	63
Fascio-scapulo-humeral dystrophy	2		2	39
Spinal muscular atrophy	1		1	47
Myasthenia gravis	1	1		72
Radiculopathy	1		1	66

TABLE 1. *Characteristics of subjects.*

FIGURE 1. *Fixed dynamometer system being used to measure left shoulder extension.*

the system has been established (4). The FD system was calibrated with a known weight immediately prior to each assessment. The Microfet HHD (Hoggan Health Industries, Draper, UT) incorporates three strain gauges located on orthogonal planes, yielding the resultant perpendicular force applied to the transducer head (Figure 2). Measurements were recorded to the nearest lb and converted to kg for analysis. The author has also used this instrument for 2 years. Calibration checks, performed weekly with a known weight, indicated that

FIGURE 2. *Hand-held dynamometer being used to measure left shoulder extension.*

the HHD was accurate within 2%, or .46 lbs.

Procedure

Patients performed two maximal "make" isometric contractions of six muscle groups bilaterally, with simultaneous force measurement by one of the two measurement systems. Patients were instructed to exert their maximal force against the HHD, which was stabilized by the tester, or when using the FD, against the strap connecting the strain gauge to the stabilizing bars of the treatment table. Patients were given consistent coaching and encouragement with both force measurement systems. Contractions were 3 seconds in duration with 5–10 seconds of rest between contractions. Since the objective was to compare maximal strength values using the two measurement systems, the highest force attained during the two contractions was used for analysis. After 30–60 seconds of rest, contractions were repeated with the other force measurement system. The patient was then repositioned for testing of the next muscle group. Sequence of testing with the two force measurement systems was randomized. Testing positions and stabilization procedures were standardized (Table 2) and identical for both force measurement systems. The tester was a middle-aged male, 5 ft 11 in tall, weighing 155 lbs, and of average strength.

Data Analysis

Two-tailed, Student's paired *t*-tests were used to determine if differences existed between measurements obtained with the two force measurement systems. Separate *t*-tests were performed on data from each of the 12 muscle groups tested. Pearson product moment correlation coefficients were performed to determine the association between measurements obtained with the two systems. Statistical significance at a level of .05 was used.

RESULTS

Patients all appeared cooperative and eager to perform maximal contractions. All patients generated what appeared to be maximal force with both systems, as evidenced by a plateauing of force on the digital display of the HHD and on the strip chart recorder of the FD system during the time allowed.

Only one of the 12 muscle groups tested, the right dorsiflexors, demonstrated a significant difference between measurements obtained with the two systems. In that muscle group, the HHD measurements were significantly lower than measurements obtained with the FD (Table 3). Good association was found between the two force measurement systems in maximal force values with correlation coefficients from $r = .76–.90$ (Table 4).

DISCUSSION

This study used a FD for comparison with the HHD due to the

Muscle Group	Patient Position	Limb Position	Force Application (strap or hand-held dynamometer)	Tester Stabilization
Shld Ext	Supine	Shld at 90°	Proximal to olecranon	Over acromion
Elb Ext	Supine	Elb at 90°	At wrist	Over biceps
Shld Flex	Supine	Shld at 90°	Proximal to olecranon	At thorax
Elb Flex	Supine	Elb at 90°	At wrist	Over acromion at epicondyle
Dorsi	Supine	Plantar flexion	Around metatarsals	Over proximal calf
Knee Flex	Sitting	Knee at 90°	Proximal to lateral malleolus	Over anterior thigh

Shld = Shoulder, Elb = Elbow, Dorsi = Dorsiflexion, Ext = Extension, Flex = Flexion.

TABLE 2. *Test positions and stabilization.*

Muscle Group	Fixed Dynamometer			Hand-Held Dynamometer			
	$\overline{X}$	(SD) (kg)	SE	$\overline{X}$	(SD) (kg)	SE	*p*
L Shld Ext	14.9	(10.4)	2.5	12.8	(6.6)	1.6	NS
R Shld Ext	16.1	(11.2)	2.6	12.6	(6.4)	1.5	NS
L Elb Ext	7.9	(5.3)	1.2	7.8	(5.9)	1.3	NS
R Elb Ext	8.4	(5.3)	1.2	8.9	(6.0)	1.3	NS
L Shld Flex	9.0	(5.1)	1.2	9.1	(5.8)	1.4	NS
R Shld Flex	9.7	(6.0)	1.5	10.2	(7.2)	1.7	NS
L Elb Flex	11.1	(6.4)	1.3	12.3	(8.3)	1.9	NS
R Elb Flex	12.4	(7.2)	1.6	12.5	(7.4)	1.7	NS
L Dorsi	12.3	(7.6)	1.8	11.1	(6.3)	1.4	NS
R Dorsi	13.1	(8.9)	2.0	9.6	(6.0)	1.4	.01
L Knee Flex	10.4	(5.2)	1.1	12.0	(6.1)	1.3	NS
R Knee Flex	12.2	(7.0)	1.5	11.9	(6.0)	1.3	NS

L = Left, R = Right, Shld = Shoulder, Elb = Elbow, Dorsi = Dorsiflexion, Ext = Extension, Flex = Flexion.

TABLE 3. *Comparison of fixed and hand-held dynamometer.*

	r
Left shoulder extension	.86
Right shoulder extension	.77
Left elbow extension	.90
Right elbow extension	.86
Left shoulder flexion	.84
Right shoulder flexion	.80
Left elbow flexion	.85
Right elbow flexion	.84
Left dorsiflexion	.81
Right dorsiflexion	.81
Left knee flexion	.76
Right knee flexion	.76

TABLE 4. *Correlation coefficient values between fixed dynamometer and hand-held dynamometer.*

established reliability and validity of the FD system (2,4), the widespread acceptance of that system for research measurements (3,15,22,25, 35), and the elimination of the variable of tester strength with the use of that system. Our results indicate that in the muscle groups tested, HHD measurements were comparable to those obtained with a FD. The large standard deviations relative to the force values (Table 3) obtained by both force measurement systems reflect the wide variability in strength between patients. Muscle groups tested in this study were limited to those producing relatively low forces, ie., 15 kg or less, in order to compare only muscle groups that had identical stabilization procedures employed during testing. Muscle groups producing higher forces required additional stabilization procedures by the tester, making the use of the HHD impractical. Muscle groups routinely tested in this lab using the FD, but eliminated from testing with the HHD, include the knee extensors, hip extensors, and hip flexors.

Our findings are in agreement with other studies comparing the HHD to other force measurement systems. Bohannon (6) found no differences in knee extension torque measurements obtained with a Cybex II isokinetic dynamometer and an Ametek Accuforce II HHD. Torque measurements were obtained only from healthy, adult females, and three stabilization straps were utilized for subjects during measurements using both the Cybex and the HHD. Sullivan et al (32), comparing shoulder extensor torque values obtained with a Cybex II isokinetic dynamometer and a Sparks HHD, also found no differences between the two measurement systems. Measurements were performed on 14 healthy males.

Clarke, however, found HHD measurements in normal male subjects to be lower than those obtained with a cable tensiometer, strain gauge, or spring scale in measuring finger flexion and wrist extension (14). A confounding variable in this study was the type of contraction employed, ie., "break" tests with the HHD and "make" tests with the other devices.

Our correlations between the HHD and the FD were higher than those reported in two studies comparing a HHD to a Cybex isokinetic dynamometer (6,32). Sullivan et al, measuring shoulder external rotation in 14 normal males, reported a nonsignificant correlation of .52 between the two systems on the first day of testing and a significant correlation coefficient of .78 on the second day of testing (32). Bohannon, measuring knee extension torque in 20 normal females, reported an intraclass correlation coefficient of .797 (6). The correlation coefficients found in the current study are generally higher than those reported above and, according to the criteria outlined by Blesh, are in the "good" range (5). We conclude, based on

Muscle groups tested in this study were limited to those producing relatively low forces.

the lack of significant differences and the good correlations between measurements obtained from the two measurement systems, that both systems are basically measuring the same parameter, ie., maximal isometric force. Higher correlations could possibly be obtained between the two systems if there was less strength variability between patients or if more elaborate patient and measurement device stabilization procedures were utilized.

CONCLUSION

Force measurements obtained from patients with neuromuscular disease with a hand-held dynamometer may be comparable to those obtained with a fixed dynamometer, provided that testing is limited to muscle groups producing relatively low forces, ie., approximately 15 kg and less. Additional justification for the use of hand-held dynamometers in measurements of relatively low force values is therefore provided.

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