Reliability of the Lido Linea Closed Kinetic Chain Isokinetic Dynamometer

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Due to increasing emphasis on closed kinetic chain exercises in rehabilitation, there is a need to objectively quantify their effectiveness. The purpose of this study was to determine the test-retest reliability of the peak force and total work scores during a concentric isokinetic leg press pattern using the Lido Linea closed kinetic chain isokinetic dynamometer. The static calibration of force measurements was established by hanging a series of certified weights from a lever arm of known length affixed to the system's force measurement shafts. A repeated-trials, multiple-day experimental paradigm was utilized to establish the static calibration procedure's reliability. No significant difference was found between expected and observed force scores ($p > .05$). Thirty healthy, active subjects (22.5 ± 3.9 years) performed concentric isokinetic leg press exercise under maximal voluntary conditions across a velocity spectrum of 25.4, 50.8, and 76.2 cm/sec (10, 20, and 30 inch/sec) in a test-retest experimental paradigm, separated by 24–72 hours. Intraclass correlation coefficient values (ICC 2,1) across Day 1 and Day 2 for peak force and total work ranged from 0.87 to 0.94 ($p < .05$). The data indicate that the Lido Linea closed kinetic chain isokinetic dynamometer is an appropriate instrument for assessing concentric isokinetic performance during a closed kinetic chain leg press pattern.

Key Words: *muscle strength, reliability, closed kinetic chain*

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Closed kinetic chain exercise is a key component of many rehabilitation protocols, particularly those for recovery after anterior cruciate ligament reconstruction (2,10,15,17,19). With the increasing popularity of closed kinetic chain exercise in physical therapy, there is a critical need to be able to objectively quantify performance during closed kinetic chain movement patterns in order to assess the efficacy of closed kinetic chain treatment strategies (1,3,6,8,13,16,20,21).

Recently, a closed kinetic chain isokinetic dynamometer, the Lido Linea (Loredan Biomedical, West Sacramento, CA), became commercially available. The core movement performed on the Linea is a seated or supine leg press (Figure). Individual left and right limb performance measures are recorded (peak force, total work, etc.) for both bilateral reciprocal and bilateral coupled exercise. The Linea can be controlled in an isokinetic or isotonic fashion and can be used to elicit concentric, eccentric, or isometric muscle actions in the involved muscles. Furthermore, the Linea can be placed in a vertical position and double- or single-leg squats can be performed.

To perform objective performance testing during closed kinetic chain movement patterns on the Linea, knowledge of the dynamometer (the relative ability of a patient or subject to reproduce performance scores in a test-retest experimental paradigm) is critical. Previous data (4,5,7,11) are available demonstrating the reliability for measuring performance using open kinetic chain isokinetic dynamometers. Reliability, however, is specific to a particular dynamometer and movement pattern and needs to be established for any new test methodology. Therefore, the purpose of this study was to determine the test-retest reliability of peak force and total work scores during a concentric leg press pattern using the Lido Linea closed kinetic chain isokinetic dynamometer.

METHODS

Subjects

Thirty healthy, active volunteer subjects (15 males and 15 females), ages 19–24 years ($\bar{X}$ = 22.5 ± 3.9 years), with no history of lower extremity injury participated in this study. Each subject was informed of the testing procedures and potential risks of participation prior to initiation of the study and signed an informed consent document.

Instrumentation

The Lido Linea closed kinetic chain isokinetic dynamometer was used to measure performance during concentric isokinetic leg press exercise in a bilateral reciprocal pattern (Figure). Peak force and total work measures were recorded for the left and right limbs separately by the system's custom software. The criterion score of peak force is defined as the

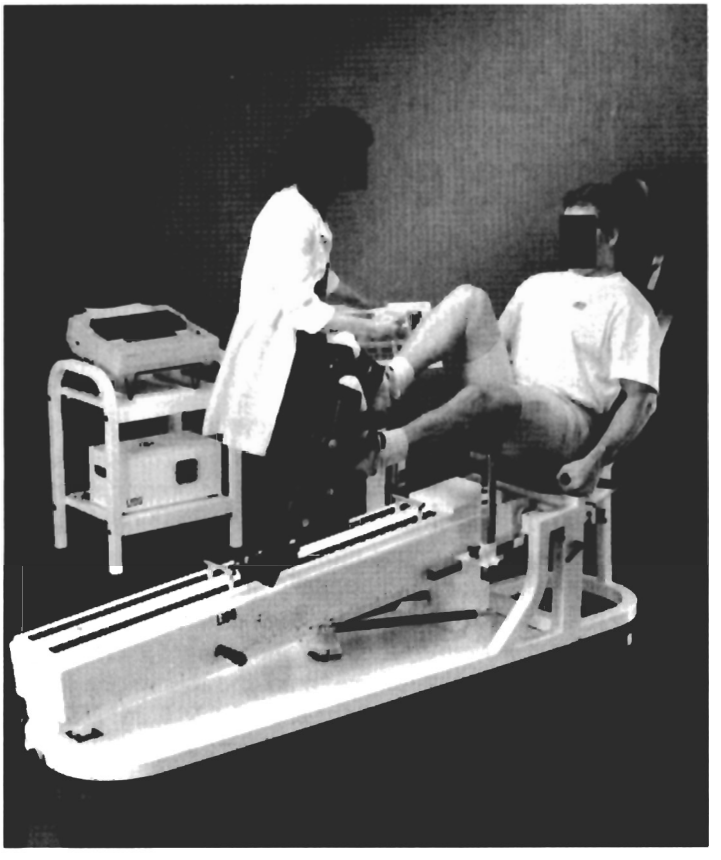

FIGURE. *The Lido Linea closed kinetic chain isokinetic system.*

maximum force (N) produced during the complete test bout of five repetitions, regardless of which repetition the peak force occurred in. The criterion score of total work is defined as the total amount of work (Nm) accomplished during the complete test bout of five repetitions.

Static Calibration Procedure

The Linea was calibrated by hanging a series of certified weights (25.0, 50.0, 75.0, 100.0, 125.0, and 150.0 kg) from a lever arm of known length affixed to the right input shaft. The lever arm is designed so that the system registers 444.8 N of additional force for each 25 kg of weight attached to it. This procedure was repeated three times per day over five successive days and also repeated using the left input shaft. The mean of the three intraday trials for each condition was used to yield a criterion force score for that day to establish the reliability of the static calibration procedure.

Test-Retest Reliability

A test-retest paradigm was used, with at least 24 hours and no more than 72 hours between sessions. Testing consisted of a velocity spectrum of isokinetic leg press exercise performed in a bilateral reciprocal pattern in the concentric mode: slow (25.4 cm/sec), medium (50.8 cm/sec), and fast (76.2 cm/sec). A total of five repetitions was recorded at each test velocity. Isokinetic velocity on the Linea refers to a constant change in the linear position of the input shafts over time.

Isokinetic testing was preceded by 5 minutes of cardiovascular and musculoskeletal warm-ups, during which each subject cycled on a Fitron ergometer (Cybex, Ronkonkoma, NY) at a self-selected, submaximal intensity. Subjects were then positioned in the Linea's leg press chair and stabilized by a lap belt. Subjects grasped the system's hand grips. With the knees fully extended, a subject's hips were in approximately 70° of flexion.

The linear range of motion (ROM) was established so that the knees would extend from approximately 90° of flexion to 5° of flexion during the complete leg press stroke. A popliteal pad was placed behind the knee at the extension end of the ROM to prevent knee hyperextension. The ROM stops and the popliteal pad's position were recorded at the first test session and replicated during the second test session.

Prior to each test, subjects performed an isokinetic warm-up of three gradient, submaximal repetitions plus one maximal repetition at each test velocity. A bilateral reciprocal repetition on the Linea is defined as a complete leg press stroke from the flexed knee position to the extended knee position for both limbs in direct succession. For the testing, each subject performed five maximal isokinetic repetitions in direct succession at each test velocity. Strong verbal encouragement was provided in a consistent fashion to encourage maximal effort. Subjects were not provided visual feedback of their performance during testing. A 1-minute rest period separated each test. The test sequence for all subjects progressed from slow to medium to fast velocities, as is common clinical practice with isokinetic testing of this nature.

Data Analysis

Means and standard deviations were calculated using standard statistical procedures. Static calibration procedure reliability was analyzed with the Dunnett Test (18). Intraclass correlation coefficients (ICC 2, 1) were calculated to analyze reliability of peak force and total work scores. Significance was set at the $p < 0.05$ level (18).

Expected Force (N)	Observed Force* (N)									
	Day 1		Day 2		Day 3		Day 4		Day 5	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
444.8	443.5	2.7	443.5	2.7	444.8	0.0	443.5	2.7	444.8	0.0
889.6	888.3	2.7	888.3	2.7	889.6	0.0	888.3	2.7	889.6	0.0
1334.5	1333.1	2.7	1333.1	2.7	1333.1	2.7	1334.5	0.0	1331.4	2.7
1779.3	1778.0	2.7	1776.2	2.7	1778.0	2.7	1776.2	2.7	1778.0	2.7
2224.1	2218.3	2.7	2218.3	2.7	2218.3	2.7	2219.7	0.0	2216.5	2.7
2668.9	2664.5	0.0	2663.2	2.7	2661.4	2.7	2664.5	0.0	2663.2	2.7

* *Criterion scores for observed force for each test day are the mean of three trials (± SD) for the right shaft.*

TABLE 1. *Observed vs. expected force values during mechanical loading.*

RESULTS

No significant difference was seen for either the calibration or test-retest reliability scores between right and left sides ($p > 0.05$). Therefore, only results for the right side are reported.

Static Calibration Procedure

No significant difference was found between expected and observed force scores for the mechanical loading tests ($p > 0.05$) (Table 1).

Test-Retest Reliability

Test-retest intraclass correlation coefficient values (ICC 2, 1) ranged from 0.89 to 0.94 for all peak force scores (Table 2) and 0.87 to 0.89 for all total work scores (Table 3) ($p < 0.05$).

DISCUSSION

The results of this study demonstrate that the static calibration procedure utilized was reliable. Further, the test-retest of the Lido Linea compares favorably with previous investigations of test-retest reliability for comparable commercially available open kinetic chain isokinetic dynamometers. The only other study to evaluate closed kinetic chain isokinetic testing was described by Levine et al (14). They performed a test-retest reliability study on 19 healthy subjects, 1 week apart, on an adapted Kin-Com isokinetic dynamometer (Chattanooga Group Inc., Chattanooga, TN). Subjects were supine and tested from approximately 115° of hip and knee flexion to full hip and knee extension. Testing was performed at 30, 120, and 210°/sec. The intraclass correlation coefficients for combined group values were 0.80–0.90 (30°/sec), 0.93–0.95 (120°/sec), and 0.90–0.96 (210°/sec). With ICCs ranging from 0.87 to 0.94, this present study had similar results to the Levine et al study.

Certain limitations must be considered when assessing the results of this study. These limitations may include the influence of practice sessions and the use of normal subjects with no lower extremity or cardiovascular problems.

No formal practice sessions were permitted prior to actually performing the test-retest reliability sequence. One reason we did not permit the practice sessions was our attempt to realistically reproduce the clinical practice setting. Often times, patients are tested on an initial or one-time patient visit to establish a database or to determine the patient's present status. Therefore, instead of including additional practice sessions which would probably increase the reliability, we were primarily concerned that the results have clinical validity.

The initial 30 subjects included in this study were normal. Consequently, we cannot generalize the results to a patient population. Nevertheless, since the test-retest reliability demonstrated good to excellent

Speed (cm/sec)	Day 1		Day 2		ICC
	$\bar{X}$	SD	$\bar{X}$	SD	
25.4	2147.2	474.4	2151.2	540.0	0.89*
50.8	1754.8	493.8	1775.3	516.9	0.94*
76.2	1386.5	466.2	1383.4	516.9	0.93*

* $p < 0.05$.

TABLE 2. *Peak force (N) mean ± SD values and intraclass correlation values (ICC) across Day 1 and Day 2.*

Speed (cm/sec)	Day 1		Day 2		ICC
	$\bar{X}$	SD	$\bar{X}$	SD	
25.4	1490.0	514.8	1445.4	520.6	0.87*
50.8	1106.8	461.0	1080.7	437.0	0.89*
76.2	792.8	357.8	775.7	336.3	0.89*

* $p < 0.05$.

TABLE 3. *Total work (Nm) mean ± SD values and intraclass correlation values (ICC) across Day 1 and Day 2.*

results, the data indicate that the Lido Linea closed kinetic chain isokinetic dynamometer can be used to attain reliable measures for assessing concentric isokinetic performance during a closed kinetic chain leg press pattern.

Recommendations for Future Research

With new sophisticated computerized testing instrumentation, there are always many questions that need to be addressed in prospective experimental research studies. Future investigations should address the: *1*) validity of the Linea closed kinetic chain isokinetic dynamometer; *2*) correlations between Linea closed kinetic chain testing and open kinetic chain testing; *3*) correlations between Linea closed kinetic chain testing and functional testing; *4*) correlations between seated Linea closed kinetic chain testing and standing Linea closed kinetic chain testing; *5*) closed kinetic chain testing of other muscle action modes, such as eccentrics (9); *6*) efficacy of training responses as it relates to selected musculoskeletal injuries and surgeries; and *7*) established parameters for effective training.

CONCLUSION

Because of increasing emphasis on closed kinetic chain exercise, it is important to measure the results of rehabilitation using this mode of exercise. The Lido Linea closed kinetic chain isokinetic dynamometer was found to be reliable in assessing peak force and total work scores using the seated leg press pattern. Continued research needs to be conducted to further establish the efficacy of a closed kinetic chain treatment program for the lower extremity (12).

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ACKNOWLEDGMENTS

The authors would like to thank Thomas Drake, Andrew Horstman, and Bill Brennan for their assistance with data collection. Thanks to the physicians (Charles Giangarra, MD, Richard Romeyn, MD, and Debra Zillmer, MD, PT) and physical therapists (Diane Fletcher Klos, MS, PT, SCS, Sue Orwoll, MS, MPT, ATC, Scott Straker, MS, PT, ATC, and Pam Johnson-Stuhr, BS, PT, ATC) at Gundersen Lutheran Sports Medicine Center for their support. Thanks to Marilyn Miller, PhD, ATC, for her assistance with the statistical analysis. Thanks to Stephen Westing, PhD, for his help in manuscript preparation. Thanks to Donna Finn for her assistance in manuscript preparation.

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