Reliability of Lumbar Isometric Torque in Patients with Chronic Low Back Pain

In this study, the test-retest reliability of lumbar isometric strength testing in patients with chronic low back pain (CLBP) was assessed. Isometric torque measurements were obtained from 89 patients with CLBP at seven different angles of lumbar flexion. Because previous studies have demonstrated significant strength differences between male and female subjects, separate data analyses were performed for each gender. Results indicated moderate to high reliability for patients with CLBP when tested at individually determined angles of flexion within their idiosyncratic range of motion (ROM) (female subjects: r=.59–.96, P<.05, SEE=12.0–24.2 N·m; male subjects: r=.71–.93, P<.05, SEE=25.1–62.1 N·m). For comparison with previously published data on asymptomatic controls, an additional set of analyses was conducted for subjects with full lumbar ROM. Similar reliability was demonstrated for this subsample (female subjects: r=.57–.93, P<.05, SEE=12.4–27.9 N·m; male subjects: r=.63–.93, P<.05, SEE=34.2–44.2 N·m). The authors concluded that isometric lumbar extension torque could be reliably measured in patients with CLBP at multiple positions within the full ROM, although reliability decreased at the most extended positions. The demonstrated reliability will allow researchers to assess treatment effects and group differences without undue concern for artifact attributable to measurement error. [Robinson ME, Greene AF, O'Connor P, et al. Reliability of lumbar isometric torque in patients with chronic low back pain. Phys Ther. 1992;72:186–190.]

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Key Words: *Isometric strength, Low back pain, Reliability.*

Low back pain is currently one of the most widespread and costly medical problems, afflicting as many as 80% of the population and resulting in an estimated 19 million physician visits per year.[1] A large proportion of low back problems are believed to be of a muscular origin or have skeletal muscle involvement.[2] Although 80% of individuals with back pain return to work within 6 weeks,[3] one out of five patients with back pain will become severely disabled.[4]

Modern treatment of low back pain, especially chronic low back pain (CLBP), has become increasingly multidisciplinary and is likely to include psychology, physical therapy, medicine, occupational therapy, and vocational rehabilitation. The treatment of patients with CLBP often includes rehabilitation of the back muscles. In addition to traditional physical therapy modalities aimed at increasing endurance, flexibility, and overall muscular strength, we believe clinicians have

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This study was approved by the University of Florida at Gainesville Institutional Review Board.

This article was submitted April 22, 1991, and was accepted September 19, 1991.

become interested in devices designed to increase the strength of the lumbar musculature. Clinicians apparently believe that strengthening the back musculature will aid the patient with low back pain by increasing physical functioning and offering protection for the spine from trauma and daily physical stressors.

Testing of workers and patients to determine the presence or absence of lumbar spine disorders has become widespread because of the significant economic impact of these disorders. These tests are used for predicting back injury,[5] assessing the functional capacity of workers,[6] and analyzing a worker's recovery from injury.[7] The method of recording force production may be isokinetic,[7] isometric,[8] or isoinertial.[9]

Graves et al[8] have reviewed the requirements for effective assessment of lumbar muscle performance. These requirements include (1) stabilization of the pelvis, (2) evaluation through a full range of motion (ROM), (3) standardization of the testing position, and (4) correction for the effect of body weight. They note that the majority of previous studies assessing lumbar muscle function did not meet these requirements and thus yielded questionable data. The lumbar extension machine used in their study met their requirements. The results of their study indicated that, when the lumbar extensor muscles are isolated through pelvic stabilization and careful attention is given to standardization of the testing position, isometric lumbar extension torque measurements are reliable for a population of asymptomatic individuals.

Although the methodology reported by Graves et al[8] has subsequently been used with success to evaluate lumbar extension torque in asymptomatic adults,[10,11] its application in patients with CLBP has not been explored. The purpose of this study was to evaluate the reliability of isometric lumbar extension torque measurements in patients with CLBP. We used a new apparatus in this study that meets the requirements of pelvic stabilization, multiposition evaluation through full ROM, standardized testing position, and correction for body weight.

Method

Subjects

Two groups of patients with CLBP participated in this study: a male group (n=45) and a female group (n=29). Diagnoses were available for 68 of the subjects. Forty-seven percent of these patients had undergone surgery (postlaminectomy syndrome, intact fusion). Fifty-three percent of these patients had not undergone surgery. These subjects had diagnoses of myofascial pain syndrome (no radiographic evidence of disk abnormality or instability) or radiographically supported diagnoses of degenerative disk disease. We believed, based on orthopedic examination, including radiography, that all subjects were free of spinal instability. The subjects participated in the testing procedure as part of their routine physical conditioning under the direction of an orthopedic surgeon and a physical therapist. Informed consent was obtained from all participants.

Procedure

Two isometric lumbar torque tests were administered to each subject. Testing consisted of determining maximal voluntary isometric torque from the lumbar musculature at seven angles of lumbar flexion with a MedX(TM)* lumbar extension machine. Those individuals with full ROM (0°–72°) were tested at 0, 12, 24, 36, 48, 60, and 72 degrees of lumbar flexion. Individuals without full ROM were tested at seven equal intervals of their idiosyncratic ROM. This was done by subtracting their maximum flexion value from their maximum extension value and dividing this ROM into seven separate angles.

Subjects were seated in the lumbar extension machine, and femur and lap restraints to stabilize the pelvis were positioned and tightened. The femur restraints consisted of two adjustable pads that could be tightened by crank against the anterior side of the tibia at the level of the tibial tuberosity. The lap restraint consisted of a thick, padded belt that was tightened over the top of the femurs just below the hip joint. These restraints forced the femurs upward and to the rear while pushing the pelvis back against a specially designed pelvis restraint. Vertical movement of the pelvis was controlled by the thigh restraints. A headrest adjusted to the level of the occipital bone allowed for comfort and support of the head. Two handlebars attached to the back pad allowed for standardization of arm position. As pushing on the handlebars could not aid the subjects in increasing lumbar support, the subjects were instructed to maintain a light grasp throughout the testing procedure.

After the position was standardized and the pelvic restraints tightened to stabilize the pelvis, each subject was moved to a neutral, upright position (15°–36°) to establish the center line of the torso mass. At this time, a counterweight was locked into place. The counterweight necessary to neutralize the gravitational forces of the head, torso, and upper extremities was adjusted while the subject rested against the back pad at 0 degrees of flexion (maximum lumbar extension).

Isometric testing began by locking each subject into the position of maximum lumbar flexion for that subject. The subject was then instructed to gradually and continuously extend the back against the back pad for 6 seconds. A 10-second rest period was allowed between each isometric contraction while the next angle of flexion was set. The same procedure was followed for each of the seven angles of lumbar flexion. Subjects were encouraged to give their maximal effort.

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Table 1. *Lumbar Isometric Torques (in Newton-meters) for Male Subjects with Chronic Low Back Pain Using All Available Standard Test Angles*

Angle of Flexion (°)	N[a]	Test $\bar{X}$	Test SD	Retest $\bar{X}$	Retest SD
72	15	381.5	158.2	391.8	135.6
60	17	328.1	112.5	366.6	119.0
48	17	306.2	104.1	340.2	104.2
36	18	276.4	113.2	304.3	107.6
24	22	218.6	128.6	251.3	103.1
12	24	199.2	83.7	192.2	83.5
0	45	128.5	69.4	133.3	80.5

[a]N represents the number of subjects tested at each standard angle. Because of limitations in range of motion, some subjects were not tested at all standard angles.

Isometric testing was repeated 15 minutes later to assess the reliability of the torque measurements. To standardize the clinical procedure and thus increase ecological validity (ie, generalizability to the clinical setting), all subjects were tested in a fixed order (ie, flexion to extension).

Data Analysis

Maximal voluntary torque values (in newton-meters) were obtained for each subject at each of the seven test positions. These measurements were obtained in both test sessions. Reliability was assessed via Pearson Product-Moment Correlation Coefficients *(r)*, standard error of the estimate (SEE), and total error (E) at each of the test angles. The SEE and E were calculated with the following formulas:

(1) $$SEE = Sy_{12}\sqrt{1-r^2}$$

where

$$Sy_{12} = \sqrt{\frac{(Sy_1^2+Sy_2^2)}{2}}$$

(2) $$E = \sqrt{\frac{\Sigma(y_1-y_2)^2}{N}}$$

Descriptive statistics (means and standard deviations) were calculated at each test angle for the subjects with full ROM.

Results

Separate data analyses were conducted for the male and female subjects. The test-retest torque values for the male and female subjects are presented in Tables 1 and 2, respectively. Thirty-three percent of the male subjects had the full 72 degrees of flexion, and 100% could extend to the 0-degree position. Fifty-six percent of the female subjects could flex to 72 degrees, and 97% could extend to the 0-degree position.

Table 3 summarizes the test-retest reliability coefficients derived from the patient data. The data strongly indicate that the MedX™ apparatus yields reliable measurements. For male subjects, the coefficients ranged from .66 to .93. Female subjects achieved similar reliability coefficients, ranging from .59 to .96. All reliability coefficients were significant at the .001 level. The reliability of the test-retest results was only moderate at the more extended positions (12° and 0°).

Stability of the obtained torque values was examined by separate multivariate analyses of variance (MANOVAs) for male and female subjects, using the seven torque values as dependent variables and time (test-retest) as a repeated factor, to determine whether values differed between the two tests. For the male subjects, no significant test-retest effect was observed (Wilk's $\lambda=.81$; $F=1.3$; $df=7,38$; $P=.30$). The female subjects' MANOVA results suggested a significant test-retest difference (Wilk's $\lambda=.45$; $F=2.6$; $df=7,22$; $P=.04$). Paired *t* tests on each test position conducted as a follow-up to the female subjects' significant MANOVA results indicated that there was a significant increase in torque production at the most flexed position at retest ($t=2.9$, $df=28$, $P=.008$). When a Bonferroni correction is applied for multiple comparisons, this result is not considered significant. No other *t*-test

Table 2. *Lumbar Isometric Torques (in Newton-meters) for Female Subjects with Chronic Low Back Pain Using All Available Standard Test Angles*

Angle of Flexion (°)	N[a]	Test $\bar{X}$	Test SD	Retest $\bar{X}$	Retest SD
72	15	171.6	59.2	200.3	43.0
60	16	172.9	49.0	181.9	38.5
48	16	164.7	42.1	165.6	44.3
36	15	150.2	44.2	153.2	44.7
24	21	121.8	43.5	122.9	42.4
12	21	107.5	44.2	103.1	47.6
0	27	82.2	46.4	76.6	38.9

[a]N represents the number of subjects tested at each standard angle. Because of limitations in range of motion, some subjects were not tested at all standard angles.

Table 3. *Test-Retest Isometric Torque Correlations (r), Standard Errors of Estimate (SEE),[a] and Total Errors (E) for All Subjects[b]*

Angle of Flexion (°)	Male Subjects (n=45)			Female Subjects (n=29)		
	r	SEE	E	*r*	SEE	E
72	.93	25.1	49.2	.92	24.2	36.7
60	.90	39.1	57.3	.94	21.1	29.3
48	.88	38.3	55.0	.96	14.5	26.4
36	.88	38.8	55.0	.95	15.5	20.7
24	.66	62.1	87.0	.92	16.4	24.1
12	.74	44.5	63.4	.83	12.0	32.3
0	.71	40.5	57.1	.59	22.9	39.6

[a]SEE values are in newton-meters.

[b]All correlations significant at $P<.001$.

results approached significance. These results suggest that there does not appear to be a significant learning effect for repeated testing within the test parameters of this study.

For comparison with previously published findings,[8] test-retest correlations were calculated for a subsample of subjects who could be tested at the standard test angles. Similar results were obtained. For male subjects, the correlation coefficients ranged from .63 to .93. For female subjects, the correlation coefficients ranged from .57 to .93. All correlations were significant at the .001 level. The same general pattern of significant, but lesser, reliability at the more extended positions was evident in this subsample. These results are summarized in Table 4.

As has been shown in asymptomatic subjects,[8] more torque was produced in the most flexed positions. This relationship is illustrated in the Figure.

Discussion

The unique aspect of this study was the demonstration of the reliable assessment of lumbar extension torque at multiple positions throughout the ROM in patients with CLBP. These data suggest that the MedX(TM) apparatus may be used to reliably measure lumbar extensor torque in patients with CLBP. Reliable torque production was observed in those subjects with restricted ROM as well as in those subjects who were testable at standardized test angles. Reliability of measurements was greater in the more flexed positions for both male and female subjects (r=.93 versus .71 for male subjects, r=.92 versus .59 for female subjects). The lower reliability at the most extended positions may be related to decreased variability in these measurements, as the least torque was produced at these positions. In addition, there was little evidence of a significant learning effect, which may allow for abbreviated testing sessions in the clinic.

Clinical Implications

The establishment of a reliable measure of lumbar extensor torque throughout a 72-degree ROM in patients with CLBP suggests a number of clinical implications. Identification of abnormalities by examining the torque-by-angle relationship for deviations from the norm may be useful. These abnormal profiles may then be targeted for further clinical research and addressed in treatment. Reliable measurement of lumbar extensor torque in a clinical population also makes the evaluation of various treatment modalities possible, with fewer concerns about the possibility of measurement artifact.

Conclusions

The results of this study show that lumbar extensor torque measurements can be reliably obtained in individuals with CLBP. This procedure meets the requirements of pelvic stabilization, multiple position testing through a full ROM, standardization of the test position, and correction for body-weight influences, which are likely to have contributed to the reliability obtained in the study. The

Table 4. *Test-Retest Isometric Torque Correlations (r), Standard Errors of Estimate (SEE),[a] and Total Errors (E) for Subjects with Full Range of Motion Tested at Standard Angles of Lumbar Flexion[b]*

Angle of Flexion (°)	Male Subjects (n=45)			Female Subjects (n=29)		
	r	SEE	E	*r*	SEE	E
72	.93	38.9	57.3	.78	15.7	46.8
60	.88	40.1	67.4	.86	16.4	26.9
48	.89	34.2	58.6	.91	12.9	18.6
36	.87	39.7	61.7	.93	12.4	17.1
24	.63	42.9	105.0	.87	15.3	20.6
12	.72	44.2	61.8	.80	20.8	29.5
0	.71	40.4	57.1	.57	27.9	39.6

[a]SEE values are in newton-meters.

[b]All correlations significant at $P<.001$.

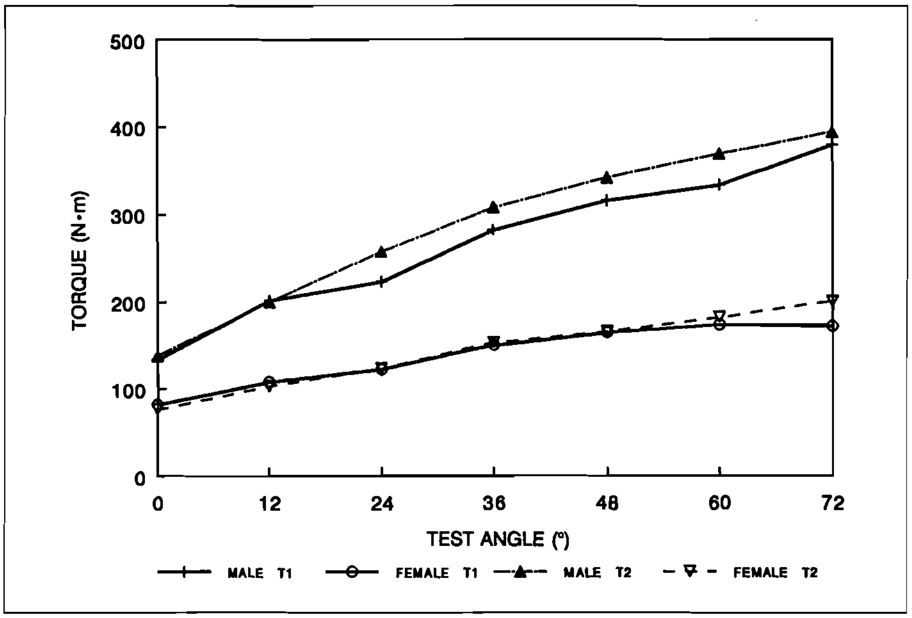

Figure. *Schematic of mean test (T1) and retest (T2) torque measurements (in Newton-meters) for male and female patients with chronic low back pain.*

demonstrated reliability of the measurements will enable the clinician to make treatment recommendations and to evaluate treatment effectiveness more accurately.

Future research aimed at investigating the effectiveness of strength and endurance training on the functional rehabilitation of patients with CLBP is indicated. Additional studies aimed at determining the relationship of pain inhibition, voluntary submaximal effort, and fear of injury to torque measures may also increase understanding of abnormal torque-by-angle relationships in clinical populations.

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