Test-Retest Reliability of the Biodex Isokinetic Dynamometer

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The purpose of this study was to determine the test-retest reliability of the Biodex (Biodex, Corp., Shirley, NY) isokinetic concentric mode for a healthy active population for knee extension/flexion utilizing the parameters peak torque and work. Nineteen healthy active male and female subjects ages 20–35 with no history of knee injury were tested bilaterally for concentric knee extension and flexion at 60, 180, 240, and 300°/sec., utilizing standard Biodex protocol. Seven days following the pre-test, a post-test was administered using identical protocol. Data collection of pre- and post-testing was done via a Compaq Desk Pro personal computer and Biodex software programming. The parameters of peak torque and single repetition work were analyzed for knee extension/flexion. Statistical analysis of data showed the intraclass correlation coefficient (ICC) of knee extension peak torque at 60°/sec to be r = 0.95; at 180°/sec, r = 0.96; at 240°/sec, r = 0.95; and at 300°/sec, r = 0.97. Knee extension work ICC values were at 60°/sec, r = 0.96; at 180°/sec, r = 0.97; at 240°/sec, r = 0.96 and r = 0.95 at 300°/sec. All ICCs are significant at the 0.05 level. Therefore, the isokinetic concentric mode of the Biodex dynamometer was reliable for test-retest measures of peak torque, and single repetition work.

Since the introduction of the concept by J. J. Perrine in the early 1960s (7), isokinetic exercise has become an integral part of rehabilitation and testing of musculoskeletal injuries in orthopaedic and sports physical therapy (6, 9, 12). Isokinetic exercise is characterized by a fixed speed and a variable resistance that accommodates to the individual throughout the range of motion.

For the past decade, nearly all the isokinetic research and testing in the literature has been done on the Cybex II® (Lumex Corp., Ronkonkoma, NY) isokinetic dynamometer. Test-retest studies by Alexander and Molnar (1, 9) on 500 "normal" children have shown high reliability with isokinetic measurement using the Cybex II. Earlier work in 1969 by Moffroid et al. (8) established the reliability of the isokinetic dynamometer for the measurement of torque, work, and power. Isokinetic data presented in these earlier studies were recorded on either single or dual-channel, heat-sensitive recorders.

Current research has centered on test-retest reliability of the Cybex II interfaced with the Cybex data reduction computer (CDRC) (Lumex Inc., Ronkonkoma, NY). Barbee and Landis (2) found significant correlation on peak torque, work, and power but very low correlation on torque acceleration energy. Perrin (10) published work on the Cybex II with the CDRC and found significant test-retest reliability on peak torque, work, average power, and torque acceleration energy measurements.

The increased use of isokinetics in the field of orthopaedic and sports medicine has resulted in the presence of several isokinetic devices. However, study of available research shows little in the area of test-retest reliability of some of these new devices. Tredinnick and Duncan (11) tested 14 males in a test-retest investigation on the Kincom (Chattex Corp.) isokinetic dynamometer, as did Farrell and Richard (4). Francis and Hobbler (5) tested 21 subjects on the Cybex II and Lido (Davis, CA) isokinetic dynamometers. Test-retest correlation coefficients for the Cybex II and Lido were $r = 0.90$ and $r = 0.85$, respectively. Correlation coefficients are considered to be highly reliable for measures involving isokinetic testing.

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Francis and Hoobler (5) found significant differences between measurements on the same subject population between the Cybex II and Lido on quadricep and hamstring peak torque, as well as the quadricep/hamstring ratio. There is little evidence in the literature at this time on test-retest reliability for other isokinetic dynamometer systems. The purpose of this study was to determine the test-retest reliability of the Biodex isokinetic dynamometer (Shirley, NY) concentric mode.

MATERIALS AND METHODS

Subjects

Nineteen healthy, active subjects (10 female and 9 male, ages 20–35) with no past history of lower extremity injury participated in this study. All 19 subjects were participating in an exercise activity a minimum of three times weekly at the time of the study. Subjects were not accepted if they were weight training their lower extremities during this investigation. Subjects were asked not to alter their physical activities between the two testing sessions.

Materials

A Biodex (Biodex Corp., Shirley, NY) isokinetic dynamometer was used for all testing with Bioware (Biodex Corp., Shirley, NY) computer software used for data recording and reduction. A Compaq desk pro personal computer was used to run all statistical and testing procedures. A Fitron (Lumex Corp., Ronkonkoma, NY) lower extremity cycle was used in the warm-up procedure.

Method

Each subject completed a written informed consent prior to any procedure used in this experiment. This study consisted of two identical testing sessions 7 days apart. Subjects were tested at similar times of day to control for possible variability from diurnal influence.

Prior to isokinetic testing, each subject completed the warm-up phase. This consisted of 10 minutes with an external heat application via hydrocollator packs, followed by dynamic warm-up of lower extremity cycling on the Fitron bicycle. Cycling was meant to be submaximal in nature and was done for 5 minutes using a pedal rpm of 90, and target rpm reading of 750.

Following the warm-up phase, each subject was tested for concentric isokinetic knee flexion and extension on the Biodex dynamometer. The subjects were seated and secured according to standard Biodex procedure using shin, thigh, pelvic, and upper crossing torso stabilization straps (3) (Fig. 1). The subject was asked to cross his or her arms and not hold the testing chair or dynamometer head during the testing procedure. The dominant lower extremity was tested first in both sessions, following subject questioning to determine unilateral dominance.

Concentric isokinetic knee flexion and extension was tested at 60, 180, 240, and 300°/sec. These speeds were chosen due to the dominance of their use in past isokinetic literature (1–12). Testing at each speed consisted of several submaximal warm-up repetitions followed by two to three maximal warm-up repetitions. Following the warm-up repetitions, five maximal concentric isokinetic repetitions were used for data collection at 180, 240, and 300°/sec and three maximal repetitions at 60°/sec. A range of motion of 0° extension to 100° flexion was targeted on all subjects. Biodex testing parameters were executed as recommended for the knee adaptor as per the Biodex Applications Manual (3). After testing the dominant, the nondominant lower extremity was tested using the same procedures and stabilization.

Seven days after the initial testing session, all 19 subjects were retested using the same procedure and warm-up. Data reduction based on 38 measurements was accomplished via Bioware, Biodex's computerized software. The Biodex software package automatically compensates for the effect of gravity. Data were collected for the parameters of peak torque, single repetition work, and range of motion. Peak torque is the highest point on the torque curve regardless of its location in the range of motion. Single repetition work is the area under the torque curve, achieved in a single repetition.

Statistical Analysis

All statistical procedures were carried out using SPSS/PC+ (SPSS Inc., Chicago, IL) a statistical analysis package modified for the personal com-

Figure 1. Subject position and stabilization setup for testing procedure with Biodex System at Lincoln Institute for Athletic Medicine.

puter. Assessment of test-retest reliability required the generation of an intraclass correlation coefficient (ICC). Statistical significance for this study is based on the $p < 0.05$ level.

RESULTS

Analysis of the intraclass correlation coefficients (Table 1) showed the test-retest reliability of the Biodex's concentric mode to be high for the measurements of peak torque and work at all testing speeds. The ICC extension values ranged between 0.95 and 0.97 for peak torque, and 0.95 and 0.97 for work. The ICC flexion values ranged between 0.82 and 0.99 for peak torque and 0.93 and 0.96 for work.

DISCUSSION

The test-retest data presented in this study for the Biodex isokinetic dynamometer show correlation coefficients similar to those reported for the Cybex II (2, 6) with computer interfacing. Barbee and Landis (2) reported coefficients from 0.91–0.97, 0.85–0.97 for peak torque and work, respectively, on the Cybex II, as did Perrin (9), whose ranges were from 0.84–0.93 for peak torque and 0.91–0.96 for work. Data listed above for the Cybex and Biodex are statistically significant at the 0.05 level and indicate a high degree of test-retest reliability. It is imperative in the field of orthopaedic and sports medicine that the clinician has a reliable tool for the assessment of muscular strength. The findings from this study suggest that the Biodex is capable of measuring muscular force production reliably.

A methodological fault present in this study was the testing of the dominant extremity first. This may have biased the data due to the presence of a motor learning phenomena which would favor the later tested nondominant extremity and negate a difference in lower extremity strength. A random selection of the dominant or nondominant lower extremity as the first to be tested may have altered the results.

Comparison of our work data from the Biodex to the Cybex, Lido, or KinCom is not possible at this time due to the absence of a single repetition work value in their software data reduction systems. The Biodex measures the work of a single repetition, whereas the Cybex measures the total work from the specified testing repetitions. The authors of this study feel single repetition work is a very important parameter for assessing rehabilitation muscle strength when comparing to the uninvolved extremity or descriptive data. Attaining muscular force production scores at one point in the range of motion (peak torque) as opposed to the whole range of motion (work) is questioned when assessing the stabilizing role of dynamic muscle activity around a joint.

TABLE 1

Intraclass correlation coefficients for peak torque and single repetition work for males and females

Speed	Extensors		Flexors	
	Peak Torque	Work	Peak Torque	Work
°/sec				
60 Means:	0.95	0.96	0.98	0.94
180 Means:	0.96	0.97	0.93	0.95
240 Means:	0.95	0.96	0.93	0.96
300 Means:	0.97	0.95	0.82	0.93

All value significant at 0.05 level (F statistic)

CONCLUSION

The Biodex isokinetic concentric mode was found to produce highly statistically significant test-retest reliability measurements of muscular performance. Information from this study is clinically important as reliability of isokinetic muscular performance measurement is imperative to interpretation and application of rehabilitative and conditioning programs in orthopaedic and sports physical therapy. ❑

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