Reliability of isokinetic Measures

By: David H. Perrin, PhD, ATC

Perrin, D.H. (1986). Reliability of isokinetic measures. Athletic Training, 21, 319-321.

Abstract:
Isokinetic resistance is frequently used to strength profile healthy athletes and to evaluate the status of injured athletes involved in rehabilitation programs. The purpose of this investigation was to determine the reliability of peak torque, torque acceleration energy, endurance ratio, average power, and total work measures obtained with a Cybex isokinetic dynamometer. Fifteen college students underwent a test - retest procedure for right and left knee flexion and extension, shoulder flexion and extension, and shoulder internal and external rotation. Highest reliability coefficients were found for peak torque, torque acceleration energy, average power, and total work measures. Lower coefficients were observed for the endurance ratio measure. Higher reliability was generally observed for the knee extension/ flexion test procedure than for the shoulder tests.

Article:
Since the use of isokinetic exercise by Hislop and Perrine (5), Moffroid et al. (10), and Thistle et al. (15), the procedure has received increasing interest in sports medicine research and clinical practice. Its usefulness in research has included examination of the relationship of muscle strength to fiber type and metabolic enzyme activity (16), the effects of training and performance on muscular strength and endurance (7), the influence of limb speed on torque production (12), and the relationship of peak torque to age, sex, performance, and body weight (9, 13). In the clinical setting, isokinetic exercise is used to evaluate the effectiveness of physical rehabilitation and to provide progressive resistance exercise therapy (3, 4).

Most clinicians assume that isokinetic dynamometers provide reliable measures of strength, power, and endurance. While some research has proven the reliability of torque measures (1, 6, 10, 11), little attention has been devoted to the reliability of power and endurance measures.

The development of a computer' interface with the Cybex apparatus has enabled the precise and rapid isokinetic measurement of peak torque, angle of occurrence of peak torque, average power, total work, torque acceleration energy, and endurance ratio (14). Barbee and Landis (2) assessed the reliability of some of these computer obtained measurements and reported coefficients of $r = .91$ to $.97$ for peak torque, $r = .86$ to $.95$ for power, $r = .85$ to $.97$ for total work, and $r = .13$ to $.27$ for torque acceleration energy.

The purpose of this investigation was to examine the reliability of peak torque, torque acceleration energy, endurance ratio, average power, and total work measures obtained with a Cybex isokinetic dynamometer interfaced with a Cybex Data Reduction Computer.

METHODOLOGY

Fifteen male college students participated as subjects in the study (mean age = 20.53 yrs, weight = 73.56 kg, height = 177.30 cm). Each subject received information regarding the testing protocol and was informed of the comparitively low risk of isokinetic testing. The subjects were given a detailed description of the study, and then asked to sign a form giving their voluntary consent to participate. Each subject was medically screened for previous injury to the knee or shoulder, and only individuals who were free of clinically significant injuries were allowed to participate.

Each subject underwent isokinetic testing for the right and left knee flexor and extensor, shoulder flexor and extensor, and shoulder internal and external rotator muscle groups during one testing session. The order of testing for muscle groups was selected in a random order and the order of the side tested was randomized for each subject in a counter-balanced order. Subjects were tested at 60°/s and at 180°/s. The slow speed was tested first in all instances to replicate protocols typically followed in the clinical setting. Test reliability was determined by repeating the complete test protocol one week following initial testing. The testing order of muscle group and side of the body during the repeat evaluation was identical to the initial test of each subject.

Peak torque measures were obtained during a five maximal repetition test at 60°/s and during a 25 maximal repetition endurance test at 180°/s. Torque acceleration energy, endurance ratio, average power, and total work measures were obtained during the 25 maximal repetition endurance test at 180°/s. Test-retest reliability was computed using the Pearson-Product correlation technique for the following isokinetic measures:

1) peak torque at 60°/s and 180°/s (i.e., the single highest point in the torque curve)
2) torque acceleration energy at 180°/s (i.e., the cork performed in the first one-eighth second of torque production)
3) endurance ratio at 180°/s (i.e., the total work done in the last five repetitions compared to the total work done in the first five repetitions of twenty-five repetitions)
4) average power at 180°/s (i.e., the total work divided by actual total contraction time)
5) total work at 180°/s (i.e., the sum total of area under all the torque curves in the test repetitions)

Table 1
Test Protocol

APPARATUS PREPARATION
AND SUBJECT ORIENTATION

WARM-UP AT 60°/s
3 SUBMAXIMAL REPETITIONS
3 MAXIMAL REPETITIONS

1 MINUTE REST

5 MAXIMAL REPETITIONS
AT 60°/s

2 MINUTE REST

WARM-UP 180°/s
3 SUBMAXIMAL REPETITIONS
3 MAXIMAL REPETITIONS

1 MINUTE REST

25 MAXIMAL REPETITIONS
AT 180°/s

MINIMUM OF 2 MINUTES
REST PRIOR TO TESTING OF
BILATERAL MOVEMENT OR OTHER JOINT

Table 3
Test-Retest Reliability for the Sample Repetitions During the Endurance Ratio Measurement

Movement Tested	First Five r	Last Five r
Knee Extension	.88	.78
Knee Flexion	.89	.85
Shoulder Extension	.83	.85
Shoulder Flexion	.77	.60
Shoulder Internal Rotation	.80	.75
Shoulder External Rotation	.91	.69

Table 4
Range of Test-Retest Reliability Coefficients for Each Isokinetic Procedure

	Peak Torque r	TAE r	Endurance Ratio r	Average Power r	Total Work r
Knee Extension and Flexion	.83-.93	.70-.86	.21-.62	.90-.95	.91-.96
Shoulder Extension and Flexion	.75-.95	.73-.93	.14-.63	.73-.88	.72-.87
Shoulder Internal and External Rotation	.74-.93	.80-.93	.19-.80	.81-.90	.80-.92

Table 2
Test - Retest Reliability Coefficients

Movement	Peak Torque left r	Peak Torque right r	Endurance Ratio left r	Endurance Ratio right r	TAE left r	TAE right r	Average Power left r	Average Power right r	Total Work left r	Total Work right r
Knee Extension 60°/s	.84	.85								
Knee Extension 180°/s	.93	.87	.41	.62	.83	.86	.94	.90	.91	.91
Knee Flexion 60°/s	.83	.92								
Knee Flexion 180°/s	.88	.89	.45	.21	.79	.70	.95	.90	.94	.96
Shoulder Extension 60°/s	.95	.92								
Shoulder Extension 180°/s	.85	.87	.63	.62	.85	.93	.88	.88	.87	.87
Shoulder Flexion 60°/s	.84	.91								
Shoulder Flexion 180°/s	.75	.77	.28	.14	.73	.85	.78	.73	.72	.79
Shoulder Internal Rotation 60°/s	.86	.92								
Shoulder Internal Rotation 180°/s	.74	.84	.57	.19	.82	.80	.81	.90	.80	.92
Shoulder External Rotation 60°/s	.91	.93								
Shoulder External Rotation 180°/s	.91	.88	.80	.64	.93	.84	.81	.87	.83	.89

Bilateral strength was measured with a Cybex II Isokinetic Dynamometer equipped with an Upper-Body Exercise and Testing Table (U.B.X.T.). The Cybex II dual channel recorder and dynamometer were interfaced with the Cybex Data Reduction Computer (C.D.R.C.) for analysis of test results. The Cybex II and C.D.R.C. were calibrated prior to the period of testing.

Subjects were stabilized with straps during testing, and the joint's axis of rotation was aligned with the input shaft of the dynamometer. To provide gravity correction during knee testing, the gravitational moment of the Cybex arm, shank, and the leg (including shoe) was determined by the C.D.R.C. (17). The length of Cybex accessories and the position of pads was noted to ensure replication during re-testing. The gravity correction obtained during the initial test was entered into the C.D.R.C. during the re-test procedure.

Each subject was verbally oriented to the fixed speed, accommodating resistance concept of isokinetic testing. After setting the apparatus for the appropriate joint, each subject followed a consistent test protocol (8) (Table 1). Verbal encouragement was provided during the test procedure to facilitate maximal effort.

RESULTS

The lowest reliability coefficients in this investigation were observed for the endurance ratio measures, and ranged from r = .14 for right shoulder flexion to r = .80 for left shoulder external rotation (Table 2). Endurance ratio is a calculation of two total work samples. To determine if a difference existed in reliability between the first and the last sample of repetitions, reliability coefficients were computed separately for the total work performed in the first sample and in the last sample repetitions (Table 3). Reliability coefficients ranged from r = .77 to .91 for the first samples and r = .60 to .85 for the last samples.

Higher reliability coefficients were observed for peak torque, torque acceleration energy (TAE), average power, and total work. Peak torque reliability coefficients ranged from r = .74 for left shoulder internal rotation at 180°/s to r = .95 for left shoulder extension at 60°/s (Table 2). Coefficients for TAE ranged from r = .70 for right knee flexion to r = .93 for right shoulder extension and left shoulder external rotation (Table 2). The reliability coefficients for average power ranged from r = .73 for right shoulder flexion to r = .95 for left knee flexion, and the coefficients for total work ranged from r = .72 for left shoulder flexion to r = .96 for right knee flexion (Table 2).

Table 4 presents the range of reliability coefficients for each isokinetic measure obtained during the knee extension and flexion, shoulder extension and flexion, and shoulder internal and external rotation test procedures. The highest reliability coefficients were observed for the knee extension and flexion procedure. The highest coefficients obtained during the knee extension and flexion test procedure were for average power and total work and ranged from r = .90 to .95 for average power and r = .91 to .96 for total work.

DISCUSSION AND CONCLUSION

Isokinetic muscular strength, power, and endurance capacity are frequently evaluated to determine the effectiveness of physical rehabilitation. As such, the importance of establishing the reliability of isokinetic measurments is important. This investigation examined the reliability of isokinetic measures obtained with a Cybex isokinetic dynamometer interfaced with a Cybex Data Reduction Computer.

Results indicated the reliability coefficients for knee extension peak torque at 60°/s and 180°/s ranged from r = .84 to .93. These were slightly lower than reported by Johnson and Siegal (6) Reliability coefficients for power and total work values obtained at a 180°/s for knee flexion and extension ranged from r = .90 to .95. These values were Blighty higher than reported by Barbee and Landis (2). TAE reliability for knee extension and flexion at 180°/s was slightly lower than reported by Barbee and Landis (2) and ranged from r = .70 to.86.

In general, this investigation found slightly lower reliability coefficients for measures obtained during shoulder extension and flexion, and shoulder internal and external rotation than knee extension and flexion. This finding may be due to the greater range of motion that is required when testing upper as compared to lower extremity isokinetic strength. It seems that the greater the range of motion required of the testing procedure, the greater the possibility of variable involvement of accessory muscle groups. Individual variation in this methodological error could have contributed to the difference in reliability of measurement between the upper and lower body.

The lowest reliability coefficients were observed for the endurance ratio measures. Unfortunately, no previous data are available for comparison of these findings. It is unclear why endurance ratio reliability was low since this measure is actually calculated from two total work measures. As previously mentioned, reliability for total work was quite high. Examination of Table 3 indicates lower reliability of total work performed in the last sample repetitions in five of six measures. This observation would seem to indicate that the breakdown in endurance ratio reliability is more related to total work in the last sample rather than first sample repetitions. Perhaps the subjects were inclined to reduce their intensity and pace their effort during the endurance retest session because of the unpleasant nature of the test.

The findings of the present investigation warrant the following conclusions:

1) Lowest reliability coefficients were observed for the endurance ratio measure. As such, clinicians should view this measure with some degree of skepticism when assessing endurance capacity of a muscle group with instrumentation similar to that used in the present investigation.
2) Highest reliability coefficients were observed for the peak torque, torque acceleration energy, average power, and total work measures. While some degree of variance exists within each isokinetic measure, it appears that clinicians can assume good reliability of instrumentation for assessment of peak torque, TAE, average power, and total work.
3) A comparison of reliability measures for the knee extension/flexion, shoulder extension/ flexion, and shoulder internal/external rotation tests reveals generally higher coefficients for the knee test.

REFERENCES

1. Alexander J, Molnar G: Muscular strength in children: preliminary report on objective standards. Archives of Physical Medicine and Rehabilitation 54: 424-427, 1973.
2. Barbee J, Landis D: Reliability of cybex computer measures (abstract). Physical Therapy 64(5): 737, 1984.
3. Cambell DE, Glenn W: Foot-pounds of torque of the normal knee and the rehabilitated postmeniscectomy knee. Physical Therapy 59(4): 418-421, 1979.
4. Gleim GW, Nicholas JA, Webb JN: Isokinetic evaluation following leg injuries. The Physician and Sportsmedicine 6(8): 75-82, 1978.
5. Hislop HJ, Perrine JJ: The isokinetic concept of exercise. Physical Therapy 47(2): 114-117, 1967.
6. Johnson J, Siegel D: Reliability of an isokinetic movement of the knee extensors. The Research Quarterly 49(1): 88-90, 1978.
7. Kelly JM, Gorney BA, Kalm KK: The effects of a collegiate wrestling season on body composition, cardiovascular fitness and muscular strength and endurance. Medicine and Science in Sports 10(2): 119-124, 1979.
8. Mawdsley RH, Croft BJ: The effects of submaximal contractions on an isokinetic test session. The Journal of Orthopaedic and Sports Physical Therapy 4(2): 74-77, 1982.
9. Miyashita M, Kanehisa H: Dynamic peak torque related to age, sex, and performance. Research Quarterly 50(2): 249-255, 1979.

10. Moffroid M, Whipple R, Hofkosh J, Lowman E, Thistle H: A study of isokinetic exercise. Physical Therapy 49(7): 735-744, 1969.
11. Murray MP, Gardner GM, Mollinger LA, Sepic SB: Strength of isometric and isokinetic contractions. Physical Therapy 60(4): 412-419, 1980.
12. Osternig LR, Sawhill JA, Bates BT, Hamhill J: Function of limb speed on torque ratios of antagonistic muscles and peak torque joint position. Medicine and Science in Sports and Exercise 13: 107,1981.
13. Rankin JM, Thompson CB: Isokinetic evaluation of quadriceps and hamstring function: normative data concerning body weight and sport. Athletic Training 18:110-114, 1983.
14. Schlinkman B: Norms for high school football players derived from Cybex data reduction computer. The Journal of Orthopaedic and Sports Physical Therapy 5(5): 243-245,1984.
15. Thistle HG, Hislop HJ, Moffroid M, Lowman EW: Isokinetic contractions: a new concept of resistive exercise. Archives of Physical Medicine and Rehabilitation 6: 279-282, 1967.
16. Thorstensson A: Muscle strength, fibre types, and enzyme activities in man. Acta Physiologica Scandinavica, Supplement 449: 7-38, 1976.
17. Winter DA, Wells RP, Orr GW: Errors in the use of isokinetic dynamometers. European Journal of Applied Physiology 46: 397-408, 1981.