The Reliability and Validity of Ankle Inversion and Eversion Torque Measurements From the Kin Com II Isokinetic Dynamometer

By: Thomas W. Kaminski, David H. Perrin, Carl G. Mattacola, Joseph E. Szczerba, and Julie N. Bernier

Kaminski, T.W., Perrin, D.H., Mattacola, C.G., Szczerba, J.E., & Bernier, J.N. (1995). The Reliability and Validity of Ankle Inversion and Eversion Torque Measurements From the Kin Com II Isokinetic Dynamometer. Journal of Sport Rehabilitation, 4, 210-218.

Abstract:
This study examined the test-retest reliability of a prototype device used to measure ankle inversion and eversion isokinetic average torque values. The purpose of this paper was to illustrate a situation where common isokinetic measures were reliable but not valid. Coneentric and eccentric average torque was assessed at 90 deg/s on the Kin Com II dynamometer using 14 healthy subjects in two sessions; a manufactured prototype ankle inversion/eversion attachment device was used. Reliability was assessed by performing separate intraclass correlations (ICC 2,1) on the results. The data indicated that the average torque calculated from the clockwise direction was consistently higher than those values from the counterclockwise direction, regardless of ankle movement or side measured. The validity of this prototype device to accurately measure average torque for these two ankle motions is questionable. This finding demonstrates a situation where the measures appear to be reliable while the validity of the device used to obtain the measures is suspect.

Article:
There are a number of research reports establishing the reliability of isokinetic instruments in assessing shoulder, hip, knee, and ankle strength (3, 5, 10-13, 24). While there appears to be an abundance of research reports on reliability, validity studies remain scarce. Tis and Perrin (23) examined the validity of data extraction techniques on the Kin Com isokinetic dynamometer. They assessed isokinetic concentric and eccentric average and peak torque of the knee extensors and flexors and concluded that extracting data from a smaller range of motion from within the tested range was a valid procedure (23). Farrell and Richards (7) showed validity and reliability of the Kin Com isokinetic dynamometer by comparing the results of measurements made from an external testing device to those made by the internal Kin Com operating system. They measured force only over the middle 25° of the lever arm stroke rather than the entire arc of motion. Aitkens et al . (1) examined the validity of the LIDO isokinetic system by dropping known weights throughout an arc of 180°. However, they measured peak torque only and did not study angle-specific torques. Patterson and Spivey (18) did a similar study of the LIDO system, monitoring the torque and velocity throughout a greater range of 200°. They applied known torques of 10.4, 25.6, 30.6, and 89.6 ft-lb to the actuator arm at a velocity of 5 deg/s (18). They demonstrated both reliability and validity within the restrictions of their study parameters.

To properly assess the success of rehabilitation, clinicians must be sure that assessment instruments are measuring both accurately and truthfully. In other words, is the instrument providing a true reflection of the phenomena? Furthermore, consumers of professional literature and research need to know that studies are based upon the use of valid and reliable assessment methods. The components of reliability and validity determine the degree of credibility that will be given to the findings (9, 17). Unfortunately, the importance of reliability often obscures the concept of validity in the practice of sports medicine.

Validity refers to the ability of an assessment instrument to measure that which it is intended to measure (2). The concept of validity implies that the findings will reflect reality and the data will be accurately interpreted (16). The common question posed concerning measurement validity is, Are we measuring what we think we are measuring? (14). Thus, there is a relationship between the instrument and the measurement it purports to make. Validity is not inherent to the instrument itself. A measurement tool is never just valid; it is valid for making a particular measurement (19). It is more helpful to think of validity as an attribute of a measurement instead of the instrument (22).

Reliability refers to the degree of reproducibility of a measurement, the extent to which the instrument yields the same measurements on repeated episodes by either the same tester or different testers. The measurement of any phenomenon always contains a certain amount of chance error. The goal of error-free measurement, while laudable, is never attained in any area of scientific investigation (4). It is necessary to realize that because repeated measurements never exactly equal one another, unreliability is always present to at least a limited extent.

A relationship exists between reliability and validity. This is best illustrated using the target-shooting analogy proposed by Sims and Arnell (22) (Figure 1). In the first target, the scores are highly reliable but not accurate (valid). In the second target, the scores are somewhat valid but have a low reliability. The third target illustrates a case where high degrees of both validity and reliability exist. This indicates that as the accuracy of the scores improves so in turn does the reliability. Measurements can be reliable yet fail to measure what they purport to measure. Reliability is a necessary but not sufficient condition for validity.

The purpose of this paper is to illustrate a situation where common isokinetic measures were reliable but not valid. This illustrates for clinicians the importance of critically examining both reliability and validity of isokinetic measurements.

FIGURE 1 IS OMITTED FROM THIS FORMATTED DOCUMENT

METHODS

Subjects

Fourteen healthy volunteers (3 men, 11 women, age = 21 ± 3.31 years, height = 170 ± 11.46 cm, weight = 69.5 ± 8.85 kg) participated in the study. To be included in this study, subjects were required to have no history of severe ankle or foot injury, no acute ankle sprain within the last year, no acute symptoms of pain or weakness in the foot or ankle, and normal range of motion. Subjects participating in any balance or strength training for the lower extremity at the time of the study were excluded. All subjects voluntarily signed a human consent form in accordance with a University Committee for the Protection of Human Subjects.

Instrumentation

The Kin Com II (Chattanooga Group, Hixson, TN) isokinetic dynamometer was used to measure concentric and eccentric average torque of the ankle invertor and evertor muscle groups. The instrument was positioned for testing with the dynamometer head tilted at a 45° angle. The test velocity was set at 90 deg/s. A specially built plinth was used to position the subject for the isokinetic ankle testing (Figure 2). This position allowed for slight hip flexion, 20' of knee flexion, and 20' of ankle plantar flexion.

The original ankle inversion/eversion attachment for the Kin Com II consisted of a square female adapter surface, which when attached to the round load cell created areas of nonuniform pressure (Figure 3). This mechanical arrangement produced measurement errors during assessment of ankle inversion and eversion peak and average torque. In response to this problem, a prototype ankle inversion/ eversion attachment device was produced by the manufacturer. It contained a completely redesigned adapter surface that was rounded to match the Kin Com II load cell surface (Figure 4). Test–retest reliability was determined using this prototype ankle attachment device.

Figure 2 — Positioning of subject for isokinetic testing of the ankle motions of inversion/eversion on the Kin Com H isokinetic dynamometer.

Test Protocol

Subjects were scheduled to participate in two sessions with at least 48 hr but no more than 10 days between test sessions. Each test session consisted of two bouts of isokinetic exercise for each ankle, one for inversion and the other for eversion. The test velocity remained constant at 90 deg/s for each exercise bout.

Inversion and eversion test sequences were determined at random. Both ankles were tested regardless of the subjects' perceived lower extremity motor dominance. The manufacturer recommendations for stabilization and joint alignment were followed for each subject. Subjects were placed supine on the inversion/eversion test table, and the foot to be tested was securely fastened into the Kin Com II foot plate attachment. The subjects were instructed to leave their shoes on to provide further stability in the foot plate. The knee was strapped to the table using a Velcro strap. The foot was stabilized in a similar fashion within the foot plate (see Figure 2). The ankle motions occurred in the transverse plane, and therefore gravity correction was not considered necessary for this test procedure.

With the aid of computer-generated commands from the ankle inversion/ eversion protocol, neutral foot position was determined by locating subtalar joint neutral. A procedure described by Donatel l i (6) was used to find the position of subtalar joint neutral when the talar head could be palpated equally on both the medial and lateral aspects of the ankle. This position was entered into the computer accordingly. Inversion start and stop angles were entered as 35° and –30°, respectively. This range allowed for a full 65° of motion from which the average torque values could be produced.

Figure 3 — Original Kin Com **II** ankle inversion/eversion attachment device. (Note the square load
cell adapter surface.)

Figure 4 — Prototype Kin Com H ankle inversion/eversion attachment device. (Note the round load cell
adapter surface.)

Subjects performed three submaximal repetitions and two maximal repetitions of ankle inversion/eversion as a warm-up. After a 60-s rest period, subjects performed three maximal test repetitions. Average torque measurements were recorded by the Kin Com II computer. The procedure was repeated on the opposite extremity following a 90-s rest period.

Data Analysis

Following the completion of all data collection, a statistical analysis was performed using the SPSS Release 4.1 Statistical Package. Average torque values were collected from the Kin Com II computer for both ankle motions tested. Individual means and standard deviations were computed for concentric and eccentric ankle inversion and eversion motions. A total of eight test and retest measures were analyzed using a two-way analysis of variance (A NOVA). Test–retest reliability was analyzed by performing separate intraclass correlations (ICC 2,1), as developed by Shrout and Fleiss (21). Standard error of measurement (SEM) values were also calculated. A total of eight ICC and SEM values were calculated from the ANOVA data.

RESULTS

Means and standard deviations for concentric and eccentric ankle inversion and eversion average torque values and associated ICC and SEM values are shown in Table I. The average torque values ranged from 98.2 to 172.5 N c m for ankle inversion and 85.5 to 162.3 N c m for ankle eversion. The associated I CC values ranged from .71 to .91 for ankle inversion and .69 to .89 for ankle eversion. As can be seen in Table l, clockwise measurements are higher than counterclockwise measurements for each measure of inversion and eversion average torque.

DISCUSSION

Our reliability coefficients ranged from .69 to .9 1, and this finding is consistent with other reports in the literature. Wong et al. (25) examined ankle inversion and eversion peak torque in women and men ranging in age from 20 to 37 years old. They assessed peak torque at 30, 60, and 120 deg/s using the Cybex dynamometer. Test and retest reliability coefficients were not reported, although the authors did obtain an ICC value of .96 for interrater reliability on the interpretation of the measurements. They found that both absolute and relative peak torque values of the invertors were consistently higher than those of the evertors in both men and women at all three test speeds (25). Leslie et al. (15) reported the reliability of isokinetic torque measures for the ankle invertors and evertors. They tested 16 women (20-33 years) at speeds of 30 and 120 deg/s, with the ankle in 0° and 20° of plantar flexion. Pearson product moment correlation coefficients were calculated on inversion and eversion peak torque values and ranged from .72 to .89 (15). The authors reported that inversion peak torque was significantly greater than eversion peak torque for all testing sequences except 0° plantar flexion at 30 deg/s on the dominant leg and 20° plantar flexion at 30 deg/s on the nondominant leg (15). Karnofel et al. (13), testing at speeds of 60 and 120 deg/s, found the mean peak torque of the invertors to be slightly higher than that of the evertors. All of their test and retest reliability coefficients were above .85, except for eversion at 60 deg/s, which had an r value of .78. The highest values were reported for plantar flexion motions at both 60 and 120 deg/s.

For our study, the inversion/eversion prototype foot plate apparatus was modified by changing the female adapter end from a square to a round receptor. This appeared to greatly reduce the three-point bending that had previously occurred due to nonuniform pressure between the load cell and adapter end. However, we noted an apparent problem in the measurement of inversion and eversion average torque. In particular, the average torque values calculated from the clockwise direction were consistently higher than the values obtained from the counterclockwise direction. The clockwise direction for inversion movements occurred when subjects were using the left ankle. The clockwise direction for the eversion motions occurred while using the right ankle. This phenomenon can be seen in Table 1, where the inversion measurements on the left side are higher while the eversion measurements on the right side are higher. These differences were present regardless of dominance. We found that the connection between the load cell and the inversion/eversion foot plate receptor end was not a perfect fit. The load cell could be placed at different positions inside the rounded receptor end, which ultimately led to errors in the torque readings. We speculated that this was one of the reasons why, when a known weight was hung from the lever arm, the Kin Com would read differently according to the position of the load cell in the receptor end. We have recommended to the manufacturer that future attachments fit snugly and possibly contain a latch system so that the female and male adapters are consistently secured in place. This finding demonstrates a situation where the measurements appear to be reliable (reproducible), while the validity of the instrument calculating these measurements is suspect. This is analogous to the example given by Sims and Arnell (22), with the first target (Figure l) depicting scores that appear reliable but are not necessarily valid.

Literature documenting the reliability of isokinetic testing devices is much more prevalent than for validity. There are a number of problems related to measurement validity that appear in the research literature. They include a failure to distinguish clearly between validity and reliability, a concentration on issues of reliability to the exclusion of validity, and, when validity is indeed addressed, methodological difficulties in its establishment (22). A critical review of the literature should include a discussion of whether both validity (accuracy) of the measuring device and reliability (consistency) have been established. Instrument validity is an essential index to identifying measurement tools that appropriately and accurately define the characteristic, event, behavior, or situation for which they have been developed (8). Tools that fail to be valid provide inappropriate and meaningless data.

The sophistication and computer interfacing of isokinetic dynamometry permit rapid and reliable measurement of muscle performance (20). However, we have illustrated in this study that reliable measurement does not ensure valid measurement. We have illustrated this point as a reminder that clinicians and researchers should take periodic steps to ensure both the reliability and validity of the instruments commonly used in sports medicine rehabilitation. For example, the mechanical reliability of dynamometers can be optimized through regular calibration. Validity can be confirmed by hanging a known weight from the lever arm to ensure accuracy in measurement of torque.

REFERENCES

1. Aitkens, S., J. Lord, E. Bernauer, and M. McCrory. Analysis of the validity of the LIDO digital isokinetic system. *Phys. Ther.* 67:757, 1987.

2. Babbie, E. *The Practice of Social Research* (5th ed.). Belmont, CA: Wadsworth, 1984.
3. Burnett, C.N., E.F. Betts, and W.M. King. Reliability of isokinetic measurements of hip musele torquc in young boys. *Phys. Ther.* 70:244-249, 1990.
4. Carmines, E.G., and R.A. Zeller. *Reliability and Validity Assessment.* Newbury Park, CA: Sage, 1979.
5. Cawthorn, M., G. Cummings, J.R. Walker, and R. Donatelli. Isokinetic measurement Of foot invertor and evertor force in three positions of plantar flexion and dorsiflexion. *J. Orthop. Sports Phys. Ther.* 14:75-81, 1991.
6. Donatelli, R. Normal biomechanics of the foot and ankle. *J. Orthop. Sports Phys. Ther.* 7:91-95, 1985.
7. Farrell, M., and J.G. Richards. Analysis of the reliability and validity of the Kinetic Communicator exercise device. *Med. Sci. Sports Exerc.* 18:44-49, 1986.
8. Fess, E.E. Using research terminology correctly: Validity. *J. Hand Ther. 1:148,* 1988.
9. Glasser, B. *Theoretical Sensitivity.* Mill Valley, CA: Sociology Press, 1978.
10. Gross, M.T., G.M. Huffman, C.N. Phillips, and J.A. Wray. Intramachine and interma-chine reliability of the Biodex and Cybex II fOr knee flexiOn and extension peak torque and angular work. *J. Orthop. Sports Phys. Ther.* 13:329-335, 1991.
11. Hageman, P.A., D.K. Mason, K.W. Rydlund, and S.A. Humpal. Effects of position and speed on eccentrie and concentric isokinetic testing of the shoulder rotators. *J. Orthop. Sports Phys. Ther.* 11:64-69, 1989.
12. Hellwig, E.V., and D.H. Perrin. A comparison of two positions fOr assessing shoulder rotator peak torque: The traditional frontal plane versus the plane of the scapula. *Isokin. Exerc. Sci. 1:1-5,* 1991.
13. KarnOfel, H., K. Wilkinson, and G. Lentell. Reliability Of isokinetic muscle testing at the ankle. *J. Orthop. Sports Phys. Ther.* 11:150-154, 1989.
14. Kerlinger, F.N. *Foundations of Behavioral Research* (2nd ed.). New York: Holt, Rinehart and Winston, 1973.
15. Leslie, M., J. Zachazewski, and P. BrOwne. Reliability of isokinetic tOrque values for ankle invertors and evertors. *J. Orthop. Sports Phys. Ther.* 11:612-616, 1990.
16. Nunnally, J.C. *Psychometric Theory*. New York: McGraw-Hill, 1978.
17. Parse, R., A. Coyne, and M. Smith. *Nursing Research: Qualitative Methods.* Bowie, MD: Brady Communications, 1985.
18. Patterson, L.A., and W.E. Spivcy. Validity and reliability of the LIDO active isokinetic system. *J. Orthop. Sports Phys. Ther.* 15:32-36, 1992.
19. Payton, O.D. *Research: The Validation of Clinical Practice* (2nd ed.). Philadelphia: Davis, 1988.
20. Perrin, D.H. *Isokinetic Exercise and Assessment.* Champaign, IL: Human Kinetics, 1993.
21. Shrout, P.E., and J.L. Fleiss. Intraclass correlations: Uses in assessing rater reliability. *Psych. Bull.* 86:420-428, 1979.
22. Sims, J., and P. Arnell. Measurement validity in physical therapy research. *Phys. Ther.* 73:102-115, 1993.
23. Tis, L.L., and D.H. Perrin. Validity of data extraction techniques on the Kinetic Communicator (Kin-Com) isokinetic device. *Isokin. Exerc. Sci.* 3:96-100, 1993.
24. Wilhite, M.R., E.R. Cohen, and S.C. Wilhite. Reliability Of concentric and eccentric measurements of quadriceps performance using the Kin-Corn dynamometer: The effect of testing order for three different speeds. *J. Orthop. Sports Phys. Ther.* 15:175-182,

1992.
25. Wong, D.L., M. Glasheen-Wray, and L.F. Andrews. Isokinetic evaluation of the ankle invertors and evertors. *J. Orthop. Sports Phys. Ther.* 5:246-252, 1984.