Reliability and validity of the Biodex system 3 pro isokinetic dynamometer velocity, torque and position measurements

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Abstract:

This study quantitatively assessed the mechanical reliability and validity of position, torque and velocity measurements of the Biodex System 3 isokinetic dynamometer. Trial-to-trial and day-to-day reliability were assessed during three trials on two separate days. To assess instrument validity, measurement of each variable using the Biodex System 3 dynamometer was compared to a criterion measure of position, torque and velocity. Position was assessed at 5° increments across the available range of motion of the dynamometer. Torque measures were assessed isometrically by hanging six different calibrated weights from the lever arm. Velocity was assessed (30°/s to 500°/s) across a 70° arc of motion by manually accelerating the weighted lever arm. With the exception of a systematic decrease in velocity at speeds of 300°/s and higher, the Biodex System 3 performed with acceptable mechanical reliability and validity on all variables tested. Keywords: Muscle function - Muscle testing - Reliability - Validity

Disclosure

The Biodex dynamometer used for this investigation was donated to the laboratory by Biodex Medical Systems. The authors have no commercial or proprietary interest in this device.

Article:

INTRODUCTION

Isokinetic dynamometers provide constant velocity with accommodating resistance throughout a joint's range of motion (ROM). This resistance is provided using an electric or hydraulic servo-controlled mechanism at a user-defined constant velocity. This type of muscle contraction has become a popular method by which to assess dynamic muscle function in both clinical and research settings. With the interfacing of isokinetic dynamometers and microprocessors,

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objective measures of human muscle function on variables related to torque, power, and endurance can be obtained. Ultimately these measures are interpreted to represent dynamic muscle function and are the basis of preseason screening, return to play decisions, treatment efficacy and insurance reimbursement. However, several measurement errors such as control of lever arm velocity (Murray and Harrison *1986*; Taylor et al. *1991*), impact artifacts (Sapega et al. *1982*), and inertial effects (Iossifidou and Baltzopoulos *2000*) attributable to the technological capabilities of the dynamometer can threaten the credibility of these measures (Farrell and Richards *1986*; Gleeson and Mercer *1996*).

Demonstrated reliability and validity is fundamental to the establishment of a credible measure of muscle function (Feiring et al. *1990*; Patterson and Spivey *1992*; Timm et al. *1992*). For measures of human muscle function using an isokinetic dynamometer to be reliable they must be both consistent and free from error, and for measures to be valid they must measure the variable they are intended to measure (Portney and Watkins *2000*). Establishing the mechanical measuring capabilities of a dynamometer without potential error introduced by variable human performance provides the first step to ensure isokinetic testing assesses clinically relevant physiological function (validity) with acceptable consistency (reliability). Use of a mechanically reliable instrument provides assurance that each time an individual is assessed, observed changes in muscle function are due to actual performance differences rather than inconsistent measurement capabilities of the instrument. Moreover, a mechanically valid instrument ensures that observations made are an assessment of a variable the clinician or investigator expected to observe. Once mechanical reliability and validity are established, the clinician or researcher is charged with the task of determining if observed changes in human performance are a direct result of applied interventions or simply an inherent inconsistency in human performance.

Measures of torque and angular velocity using a variety of isokinetic dynamometers have been found to be both mechanically reliable (Farrell and Richards *1986*; Timm et al. *1992*) and valid (Bemben et al. *1988*; Farrell and Richards *1986*; Patterson et al. *1992*). The Biodex System 3 isokinetic dynamometer (Biodex Medical Systems, Shirley, New York, USA) is a contemporary isokinetic dynamometer with an electrically controlled servomechanism used in both clinical and research settings. While previous versions of Biodex dynamometers have been shown to be reliable and valid instruments for the measurement of human function (Taylor et al. *1991*), there have been changes in the control of acceleration rates and velocity from earlier versions of Biodex dynamometers (Brown et al. *1993*; Feiring et al. *1990*; Timm et al. *1992*). Hence, no studies have evaluated the new technology provided by the Biodex System 3. Considering that Biodex is one of the few companies still manufacturing isokinetic dynamometers, establishing measurement capabilities is important for the future use of this dynamometer. Therefore, the purpose of this study was to assess the mechanical reliability and validity of angular position, isometric torque and concentric velocity measures of the Biodex System 3 isokinetic dynamometer.

METHODS

To assess both mechanical reliability and validity, each variable (position, torque and velocity) was measured three times on each of two testing days. First we established the reliability of each variable measured to ensure consistent performance between testing trials and days. Once the trial-to-trial and day-to-day test retest reliability had been determined, the validity of position, torque and velocity measures of the Biodex System 3 dynamometer and application software (version 2.15) were assessed.

During each day of testing we utilized a criterion method to measure each of the three test variables on all three trials. This criterion (C) served as the "true" value of the variable being assessed and was used as a standard to compare the Biodex System 3 generated measures of the given variable. In addition to this criterion measure, we utilized the Biodex System 3 to measure each variable in two distinct ways. First we recorded the raw voltage signal (V) generated by the dynamometer. Second, we utilized the software program (S) to generate an assessment of each variable.

Position

We set isometric test protocols in the Biodex software application program to move the lever arm in 5° increments through the entire available ROM (0° to 305°) (Fig. 1). At each increment, lever arm position was measured using a hand held inclinometer, which represented the criterion measure (C_{pos}). At each 5° increment raw voltage (V_{pos}) was acquired (5 s) from the dynamometer's electrogoniometer. At the beginning of the ROM (0°), raw voltage was collected for 5 s and averaged. This value was used as the zero offset from which to calibrate the voltage scale for each trial. The raw voltage at each subsequent increment was averaged over the 5 s trial and converted to ROM based on manufacturer specifications (13.64 mV/° – zero offset). Lastly, position as measured by the Biodex software program was recorded from the computer monitor (S_{pos}).

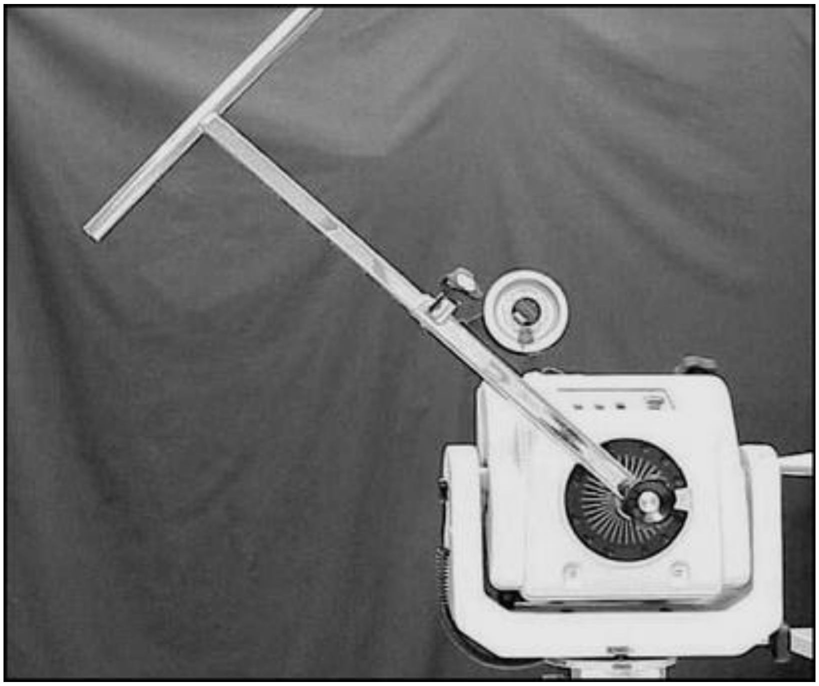

Fig. 1. Set up of angular position measures

Torque

The inclinometer was used to set a 72.5 cm lever arm perpendicular (90°) to the gravitational force (Fig. 2). In this position the Biodex System 3 measured six different torques (Nm) using calibrated weights (2.7, 6.82, 11.36, 15.91, 22.73, 29.55 kg). The moment produced by the weighted lever arm was calculated (moment arm · force = torque), and served as the criterion measure (C_{tor}). Using the isometric test mode, torque calculated with the Biodex software application program was recorded (S_{tor}). Simultaneously, raw voltage was acquired from the dynamometer (V_{tor}). The raw voltage was averaged and converted to Nm based on manufacturer specifications (277.1 Nm/V).

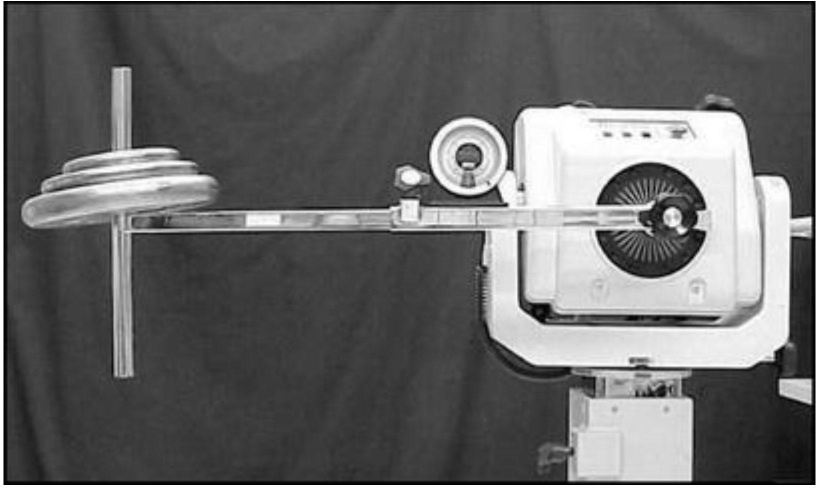

Fig. 2. Set up of isometric torque measures

Velocity

To evaluate the capability of the Biodex System 3 to control lever arm velocity, a calibrated 4.55 kg weight was placed on the end of a 72.5 cm long lever arm and manually accelerated to a range of test velocities. With the full 305° ROM available, the dynamometer was set in concentric isokinetic mode. To overcome the effects of inertia, the lever arm was accelerated manually and was then free to move through the remaining ROM (Fig. 3). Raw voltage for velocity (V_{vel}) and position (V_{pos}) were recorded during three trials, each consisting of 15 different test velocities (30, 60, 90, 120, 150, 180, 210, 240, 270, 300, 330, 360, 400, 450, 500 °/s). The test velocity set using the software program was recorded and represented the software program assessment of velocity (S_{vel}).

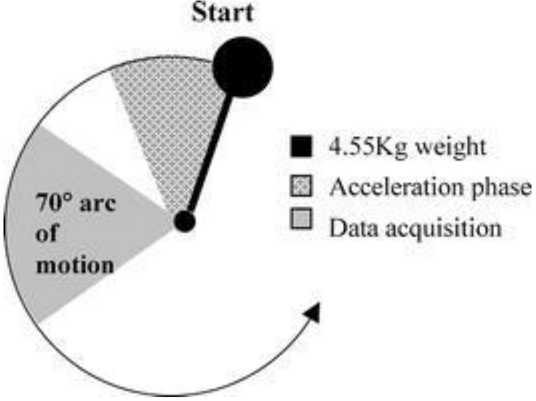

Fig. 3. Set up of angular velocity measures

Using the raw voltage for velocity (V_{vel}), we determined a ROM in which the lever arm had reached and maintained its maximum velocity during all testing velocities of a particular trial (Fig. 4). Within this ROM, we partitioned out a 70° arc of motion based on V_{pos}. This 70° arc of motion occurred during the gravity-dependent ROM and was used for data analysis (Fig. 3).

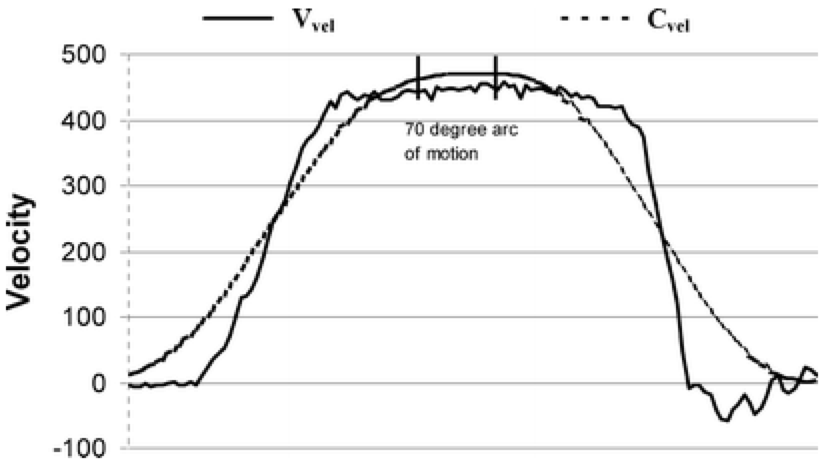

Fig. 4. C_{vel} and V_{vel} measures of velocity during the 500°/s test with the 70° arc of motion identified

After confirming the V_{pos} measure was both reliable and valid, we differentiated the position by time data (500 ms time constant) to calculate lever arm velocity for each velocity tested. We used this measure as the criterion measure of velocity (C_{vel}).

On day 1, data collected during one trial at 400°/s were not usable due to methodological error. To replace this missing value, we used linear regression to predict the value using the two existing trials. The prediction equation explained greater than 96% (multiple R^2) of the variation.

Data acquisition

Data Pac 2000 Version 1.1 Lab Application Systems software (Run Technologies; Laguana Hills, Calif., USA) was used to store and analyze raw voltage acquired from the dynamometer for each variable tested (position, torque, velocity). Sampling rates for Data Pac (500 Hz) and Biodex (100 Hz) software programs were held constant for all trials. In addition, a hand held inclinometer (Empire, Mukwonago, Wis., USA) was used for the criterion measure of angular position.

Statistical analysis

Reliability

Reliability of the three measures (*C*, *V* and *S*) for each variable was evaluated using intraclass correlation coefficients (ICC). Trial-to-trial reliability on day 1 was assessed using a 2,1 formula, while day-to-day reliability was assessed with a 2,*k* formula (Denegar and Ball *1993*; Shrout and Fleiss *1979*). We also calculated associated the standard error of measurement (SEM) for each ICC (Denegar and Ball *1993*).

Validity

Instrument validity was assessed by comparing each selected measure (*V* and *S*) to a criterion (*C*) using ICC (2,1) formulas for trials performed on day 1 (Denegar and Ball *1993*; Shrout et al. *1979*). We calculated the magnitude of discrepancy between each selected measure (*V* and *S*) and the criterion (*C*) for each variable (position, torque and velocity) for all three trials performed on day 1. The discrepancy between these measures was determined by calculating method error (ME) and the coefficient of variation of the method error (CV_{ME}). Calculated method error represents the variation (standard deviation) of the delta scores generated from two separate measures of the same variable (Portney and Watkins *2000*). To represent this standard deviation appropriately it must be presented as a value normalized to the mean of the delta scores. Therefore, we calculated the coefficient of variation of method error (CV_{ME}) (Portney and Watkins *2000*).

RESUTLS

Reliability

Intraclass correlation coefficients for trial reliability (ICC 2,1) and day-to-day reliability (ICC 2,*k*), along with associated SEMs for each variable (position, torque, and velocity) are reported in Tables 1 and 2, respectively. Observations on each variable demonstrated near perfect trial and day-to-day reliability for each measurement technique. Calculated SEMs suggest the Biodex System 3 isokinetic dynamometer was capable of accurate assessment of position and isometric torque. The high range of observed SEMs for velocity across trials on each day of testing (10.44°/s to 12.89°/s) suggested a lack of control over the velocity selected for the concentric mode of testing. As a result of this observation, we have presented the mean, standard deviation and coefficient of variation of all three trials on day 1 and day 2. The data suggest a lack of control of velocity during testing at and above 300°/s (Table 3).

Table 1. Trial-to-trial reliability assessed using intraclass correlation coefficients and standard errors of measurement. (*ICC* Intraclass correlation coefficient, *SEM* standard error of the measure)

	ICC	**SEM**
Position (°)		
Criterion measure (C_{pos}) day 1	0.99	0.45
Criterion measure (C_{pos}) day 2	0.99	0.60
Raw voltage measure (V_{pos}) day 1	0.99	0.47
Raw voltage measure (V_{pos}) day 2	0.99	0.68
Software measure (S_{pos}) day 1	1.00	0.00
Software measure (S_{pos}) day 2	1.00	0.00
Torque (Nm)		
Criterion measure (C_{tor}) day 1	1.00	0.00
Criterion measure (C_{tor}) day 2	1.00	0.00
Raw voltage measure (V_{tor}) day 1	0.99	0.001
Raw voltage measure (V_{tor}) day 2	0.99	0.001
Software measure (S_{tor}) day 1	0.99	0.39
Software measure (S_{tor}) day 2	0.99	0.30
Velocity (°/s)		
Criterion measure (C_{vel}) day 1	0.99	10.86
Criterion measure (C_{vel}) day 2	0.99	12.89
Raw voltage measure (V_{vel}) day 1	0.99	10.44
Raw voltage measure (V_{vel}) day 2	0.99	12.09

	ICC	SEM
Software measure (S_{vel}) day 1	1.00	0.00
Software measure (S_{vel}) day 2	1.00	0.00

Table 2. Day-to-day reliability assessed using intraclass correlation coefficients and standard errors of measurement. (*ICC* Intraclass correlation coefficient, *SEM* standard error of the measure)

	ICC	SEM
Position (°)		
Criterion measure (C_{pos})	0.99	2.01
Raw voltage measure (V_{pos})	0.99	0.58
Software measure (S_{pos})		
Torque (Nm)		
Criterion measure (C_{tor})		
Raw voltage measure (V_{tor})	0.99	0.57
Software measure (S_{tor})	0.99	0.29
Velocity (°/s)		
Criterion measure (C_{vel})	0.99	6.65
Raw voltage measure (V_{vel})	0.99	4.63
Software measure (S_{vel})		

Table 3. Means, standard deviations, and coefficient of variation of velocity in degrees per second during the 70° arc of motion for each test velocity averaged across trial 1, 2, and 3 on days 1 and 2 of testing. (*CV* Coefficient of variation, C_{vel} criterion velocity measure, *SD* standard deviation, S_{vel} software-measured velocity, V_{vel} raw velocity voltage)

S_{Vel}	Day 1						Day 2					
	C_{vel}			V_{vel}			C_{vel}			V_{vel}		
	Mean	SD	CV (%)	Mean	SD	CV (%)	Mean	SD	CV (%)	Mean	SD	CV (%)
30°/s	31.89	0.43	1.3	26.03	3.45	13.3	31.40	0.40	1.3	25.50	3.18	12.5
60°/s	63.41	0.81	1.3	55.65	4.01	7.2	62.61	0.62	1.0	55.43	4.26	7.7
90°/s	95.19	0.53	0.6	86.10	4.58	5.3	89.16	1.53	1.7	80.47	5.06	6.3
120°/s	126.45	0.56	0.4	116.06	4.02	3.5	126.00	0.71	0.6	115.78	4.48	3.9
150°/s	158.14	0.89	0.6	146.46	4.58	3.1	157.48	1.32	0.8	146.15	4.94	3.4
180°/s	182.21	1.83	1.0	169.06	5.10	3.0	176.61	1.93	1.1	172.26	5.16	3.0
210°/s	210.40	2.36	1.1	197.04	5.11	2.6	205.09	1.87	0.9	201.06	5.22	2.6
240°/s	252.93	2.24	0.9	237.23	4.91	2.1	247.14	2.07	0.8	242.48	5.50	2.3
270°/s	283.87	2.68	0.9	267.77	5.14	1.9	277.79	2.67	1.0	272.42	5.12	1.9
300°/s	284.69	3.71	1.3	267.89	5.78	2.2	294.75	3.15	1.1	289.72	5.68	2.0
330°/s	328.02	3.51	1.1	310.48	5.93	1.9	298.13	3.50	1.2	294.23	6.11	2.1
360°/s	359.71	4.49	1.2	341.81	6.17	1.8	326.16	3.68	1.1	322.41	6.50	2.0
400°/s	371.06	4.10	1.0	350.87	6.23	1.8	361.74	4.09	1.1	356.51	6.24	1.8

S_{Vel}	Day 1						Day 2					
	C_{vel}			V_{vel}			C_{vel}			V_{vel}		
	Mean	**SD**	**CV (%)**	**Mean**	**SD**	**CV (%)**	**Mean**	**SD**	**CV (%)**	**Mean**	**SD**	**CV (%)**
450°/s	418.60	6.39	1.5	398.35	6.69	1.7	408.33	5.66	1.4	403.34	6.80	1.7
500°/s	458.71	9.66	2.1	445.01	7.05	1.6	450.25	7.48	1.7	444.41	7.36	1.7

Validity

Intraclass correlation coefficients (2,1), method error (ME) and coefficient of variation of the method error (CV_{ME}) for each variable are reported in Table 4. The results of position and torque comparisons demonstrate near-perfect agreement between measures and associated criterions. This was also true for the range of velocities tested up to 300°/s. However, on trials exceeding 300°/s a systematic decrease occurred in the V_{vel} and the C_{vel} measures of velocity. These data suggest the lever arm did not reach the higher preset velocities.

Table 4. Discrepancy between selected measures on the average of trials 1, 2, & 3 on day one of velocity testing. (*ICC* Intraclass correlation coefficient, $Mean_d$ mean difference, SD_d standard deviation of mean difference scores, *ME* method error, CV_{ME} coefficient of variation of method error, C_{pos} criterion position measure, V_{pos} raw position voltage, S_{pos} software-measured position, C_{tor} criterion torque measure, V_{tor} raw torque voltage, S_{tor} software-measured torque, C_{vel} criterion velocity measure, V_{vel} raw velocity voltage, S_{vel} software-measured velocity)

	ICC	**Mean**$_d$	**SD**$_d$	**ME**	**CV**$_{ME}$ **(%)**
Position(°)					
C_{pos} vs.V_{pos}, trial 1	0.99	10.56	5.97	4.22	3
C_{pos} vs.V_{pos}, trial 2	0.99	10.35	5.84	4.13	3
C_{pos} vs.V_{pos}, trial 3	0.99	9.51	5.90	4.17	3
C_{pos} vs.S_{pos}, trial 1	0.99	0.16	0.44	0.31	0
C_{pos} vs.S_{pos}, trial 2	0.99	0.04	0.55	0.39	0
C_{pos} vs.S_{pos}, trial 3	0.99	0.68	0.036	0.26	0
Torque (Nm)					
C_{tor} vs.V_{tor}, trial 1	0.99	5.31	3.04	2.15	2
C_{tor} vs.V_{tor}, trial 2	0.99	5.31	3.04	2.15	2
C_{tor} vs.V_{tor}, trial 3	0.99	5.31	3.04	2.15	2
C_{tor} vs.S_{tor}, trial 1	0.99	2.91	0.82	0.58	1
C_{tor} vs.S_{tor}, trial 2	0.99	2.79	0.56	0.40	0
C_{tor} vs.S_{tor}, trial 3	0.99	2.59	0.33	0.23	0
Velocity (°/s)					
C_{vel} vs.V_{vel}, trial 1	0.99	13.15	3.34	2.36	1
C_{vel} vs.V_{vel}, trial 2	0.99	13.49	3.83	2.71	1
C_{vel} vs. V_{vel}, trial 3	0.99	13.27	3.60	2.54	1
C_{vel} vs.S_{vel}, trial 1	0.99	2.94	11.93	8.44	4
C_{vel} vs.S_{vel}, trial 2	0.99	3.16	10.67	7.54	3
C_{vel} vs.S_{vel}, trial 3	0.99	8.82	14.23	10.06	4

DISCUSSION

Our primary findings demonstrate that the Biodex System 3 isokinetic dynamometer was a mechanically reliable instrument for the valid measurement of angular position, isometric torque and slow to moderately high velocities (<300°/s) in comparison to previous reports of mechanical reliability and validity of isokinetic dynamometry (Farrell and Richards *1986*; Timm et al. *1992*). Given the mechanical reliability observed with all measures of all variables, this discussion will focus on the validity of each variable assessed.

Position

The System 3 Isokinetic dynamometer appeared capable of valid measures of angular positioning. Discrepancy between the criterion measure (C_{pos}) and the raw voltage recorded from the dynamometer's electrogoniometer (V_{pos}) was 3% ($\mathrm{CV}_{\mathrm{ME}}$) (Table 4). Since the S_{pos} measure was the specific angle in the ROM we entered into the software application program for the isometric test protocol, there was little discrepancy between the C_{pos} and S_{pos} measure. The V_{pos} measure represents the dynamometer's measure of lever arm position as it progressed through the available 305° ROM. Therefore, discrepancy observed between the C_{pos} and V_{pos} measures represent inaccuracy in the dynamometer's ability to measure lever arm position. The ME and $\mathrm{CV}_{\mathrm{ME}}$ represent the overall discrepancy between all 62 angles evaluated. However, our data suggest the largest discrepancy between the two measures occurred at the larger test angles. At the first angle measured (5° from the start angle), the difference between the C_{pos} and V_{pos} averaged across all three trials was 0.40°, while at the 305° test angle the mean difference was 19.25° (Fig. 5).

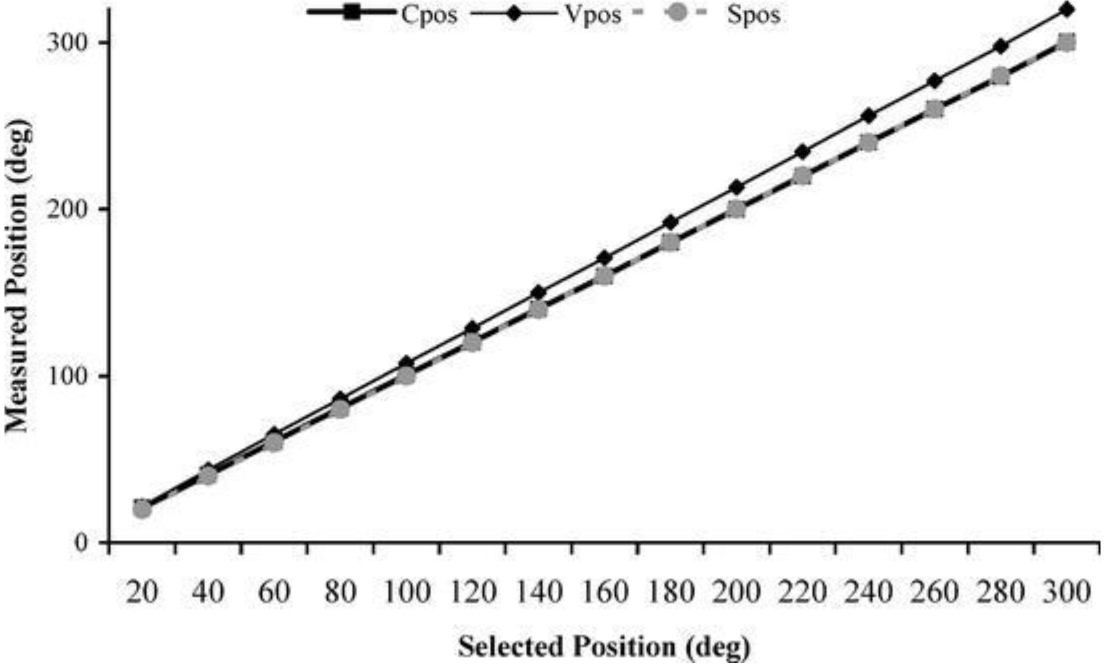

Fig. 5. Three measures (*C*, *V* and *S*) of angular position averaged across trials 1, 2, and 3 on day 1 of testing

Our methods required the dynamometer to move in 5° increments starting from 0° and progressing to 305°. By using the isometric test protocols, we were limited to six angles per test (11 tests to include all 62 angles); however, for each set of tests, the dynamometer start position was held constant (0°). Therefore, as test angle magnitude increased, so did the amount of angular deflection. We believe the discrepancy observed between C_{pos} and V_{pos} at larger test angles did not indicate inaccurate angular positioning at that specific point in the ROM. Instead, this finding indicated the dynamometer was less accurate as the degree of angular deflection increased (Fig. 5). These results do suggest that increased accuracy of angle-specific measures (such as angle-specific peak torque) could be expected with shorter angular deflections during testing.

Torque

The degree of discrepancy between the C_{tor} and S_{tor} measures suggest this particular dynamometer was capable of producing valid measures of isometric torque. The largest CV_{ME} observed between the C_{tor} and S_{tor} was 1% (Table 4). The average method error across all three trials on day 1 was 0.40 Nm. These values represent the discrepancy between the average of all six measured torques (16 Nm to 212 Nm), and as can be seen in Fig. 6, greater discrepancy was observed as selected torque measures increased. However, even at larger torques, the degree of discrepancy was negligible and would not threaten the credibility of isometric torque measures.

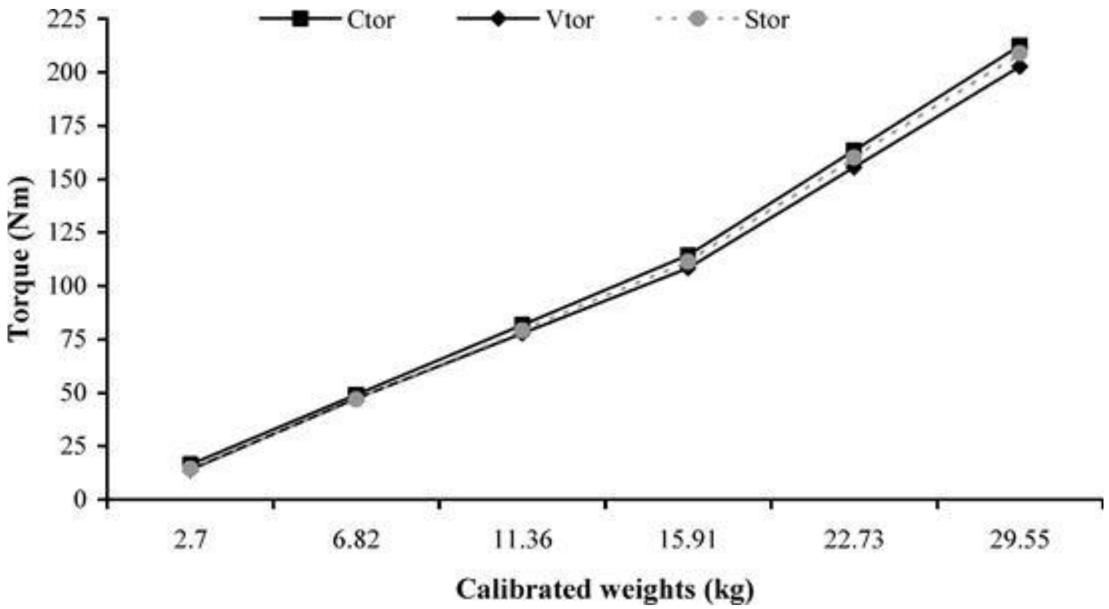

Fig. 6. Torque produced using calibrated weights assessed with selected measures as an average across trials 1, 2, and 3 on day 1 of testing

Velocity

Measures of velocity revealed the greatest degree of discrepancy when compared to torque and position variables. The ME and CV_{ME} reported in Table 4 provide evidence of discrepancy between S_{vel} and C_{vel}. These calculations were as large as10.06°/s (ME) and 4% (CV_{ME}). As can be seen in Fig. 7 and Table 3, observed discrepancies occurred primarily during test velocities at and above 300°/s. These calculations suggest the dynamometer did not attain the expected velocity and questions the validity of concentric isokinetic assessments at these faster velocities.

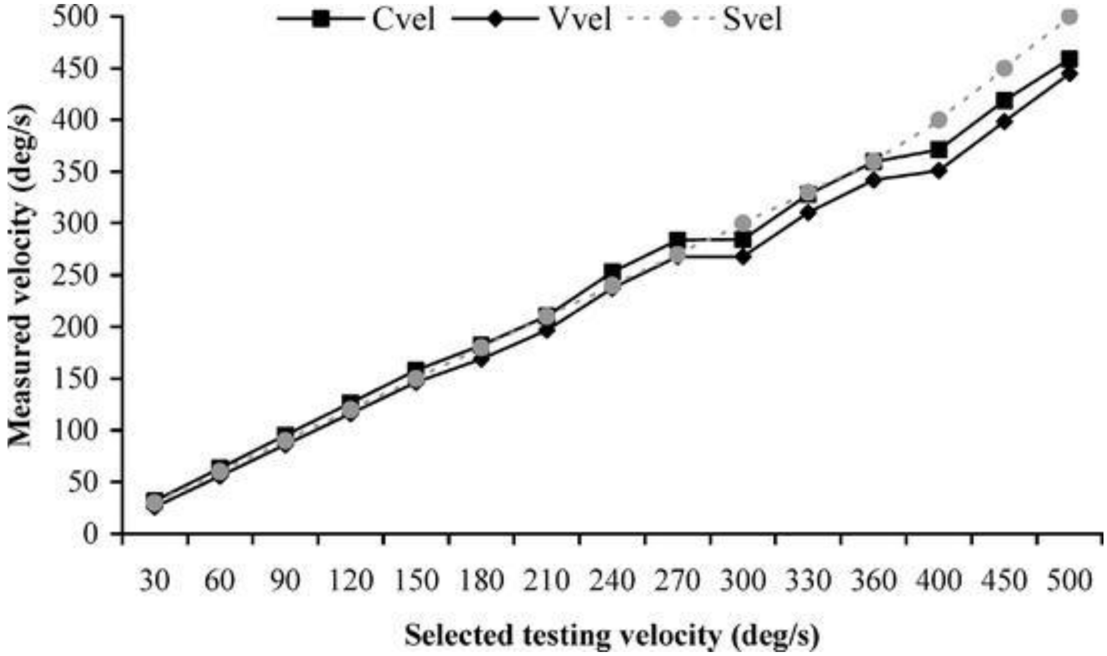

Fig. 7. Velocity averaged for trial 1, 2, and 3 on day 1 and day 2 of testing

One possible explanation for these findings involves the magnitude of torque applied to accelerate the dynamometer. Handel et al. (*1996*) demonstrated an increased magnitude of torque required to attain higher velocities given a fixed ROM for acceleration. The investigators mechanically applied a constant torque to the LIDO-Active 2.1 isokinetic dynamometer (Loredan, USA) to calculate the angular distance needed to accelerate the static lever arm to selected velocities (60 to 300°/s). Using these methods, approximately 120 Nm of torque was required to attain 240°/s in 25° of angular displacement. We did not standardize the arc of motion in which the dynamometer was accelerated during our study; however, we obtained the peak torques (PT) applied during the acceleration phase for each trial. The mean and standard deviation of the PT across all trials on both days of testing are reported in Table 5. This observation may explain discrepancies between S_{vel} and external measures of velocity (V_{vel} and C_{vel}). Using our methods to attain the selected velocity of 240°/s an average PT of 104.85 (14.75) Nm over all trials was measured. As selected velocities increased, PT measured during the acceleration phase decreased. It is likely we applied too little torque through too short a ROM to attain the higher selected velocities.

Table 5 . Means and standard deviations of peak torque occurring during the acceleration phase of velocity assessment averaged across all trials on both days. (*PT* Peak torque)

	Mean PT(Nm)	SD (Nm)
210°/s	89.77	33.20
240°/s	104.85	14.75
270°/s	103.98	14.35
300°/s	88.65	12.84
330°/s	78.88	17.41
360°/s	79.25	27.79
400°/s	57.32	15.96

	Mean PT(Nm)	SD (Nm)
450°/s	67.05	30.71
500°/s	41.32	5.92

If the failure to reach higher test velocities was in fact a function of insufficient torque applied during the acceleration phase, it brings into question the validity of high speed, "functional" assessment or training of patients during rehabilitation. Torque generation assessed at 450°/s during knee joint extension in healthy individuals has previously been reported to ranged from 68.20 to 72.13Nm (Brown et al. *1993*). Handel et al. (*1996*) reported that a 75° arc of motion was required to accelerate the lever arm to 300°/s with a constantly applied torque of this magnitude. Therefore, it is questionable if injured individuals would be able to produce the torque necessary during the acceleration phase to attain these higher velocities. Further, results of testing individuals with a decreased ability to generate sufficient torque could be reliable across trials and even days, but the validity of the test may be compromised. Brown et al. (*1993*) reported that the reliability of PT measures in healthy human participants on the Biodex system 2 obtained at 450°/s were an average of 50.3 (17.8) ftlbs (68.2 Nm) on day 1 and 53.2 (20.7) ftlbs (72.13 Nm) on day 2. The correlation between these measures was r=0.95 (Pearson Product Moment), however there was no assessment of measurement validity. Thus their results did not confirm whether participants actually attained the selected velocity. When comparing these measures to our average measures of peak torque at 450°/s [67.05 (30.71) Nm], it would appear the dynamometer was not moving at 450°/s. Similar to our findings however, day-to-day reliability observed appeared to be acceptable for both clinical and research purposes.

CONCLUSIONS

Within the limitations of this study, the Biodex System 3 isokinetic dynamometer provided mechanically reliable measures of torque, position and velocity on repeated trials performed on the same day as well as on different days. The validity of isometric torque and position measurements was acceptable for both clinical and research purposes. Concentric velocity measures were valid up to approximately 300°/s, with a systematic decrease in maximum velocity occurring at higher test velocities.

The results of this study can only be generalized to the mechanical measurement capabilities of this isokinetic dynamometer and accompanying software. Future studies must incorporate human participants to determine the reliability and validity of this instrument at assessing clinically relevant measures (peak torque, angle specific torque, etc.) of human muscle function with special attention placed on faster velocities (>300°/s). In addition, specific functions of the Biodex software application including windowing, cushioning, and filtering functions need evaluation. Lastly, no study to date has evaluated measures using the eccentric mode of this dynamometer.

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