The Reliability of Four Different Methods. of Calculating Quadriceps Peak Torque Angle-Specific Torques at 30°, 60°, and 75 °

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Arnold, B.A., & Perrin, D.H. (1993). The reliability of four methods of calculating quadriceps peak torque and angle specific torques at 30, 60, and 90 degrees. Journal of Sport Rehabilitation, 2: 243-250.

Abstract:

Twelve university females were studied to determine the reliability of four different methods of calculating concentric and eccentric peak torque (PT) and angle-specific torques (ASTs) for knee extension. Each subject was tested on the Kin-Corn isokinetic dynamometer on two separate occasions, performing five concentric and eccentric contractions at 60° PT and AST at 30°, 60°, and 75° were calculated by averaging the first three contractions, averaging all five contractions, taking the single best value of the first three contractions, and taking the single best value of all five contractions. Intraclass correlation coefficients derived from these calculations showed high correlation among the four methods. Additionally, z tests performed on correlation coefficients transformed to Fisher's Z revealed no differences between pairs of correlation coefficients. These data appear to show there is no difference among the four methods of calculating PT and AST.

Article:

In recent years isokinetics have been used extensively in rehabilitation. Frequently this includes making periodic measurements, for example, of peak torque (PT), to assess patient progress and provide patient feedback. However, the usefulness of these measures depends on their reliability. Several studies have examined the reliability of the Kin-Com (Chattecx, Hixson, TN) isokinetic dynamometer. Farrell and Richards (3) established mechanical reliability and reported intraclass correlation coefficients (ICCs) of .99 and .95 for static and dynamic conditions, respectively. Tredinnick and Duncan (12) reported intersession ICCs ranging from .75 to .89 for quadriceps concentric peak torque and .47 to .84 for quadriceps eccentric peak torque. Harding et al. (5) examined the intersession reliability of a knee flexion and extension reciprocal protocol and reported ICCs of .96 and .95 for extension and flexion, respectively. Similarly, Kramer (9) examined intersession reliability using a continuous reciprocal protocol and reported quadriceps PT ICCs ranging from .86 to .91 and .86 to .88 for conchentrics and eccentrics, respectively. Kues et al. (10) examined intersessiim reliability of knee extension peak torque using external instrumentation to achieve a sampling rate of 500 Hz as opposed to the normal 100 Hz used by the Kin-Com. They reported ICCs ranging from .94 to .98 and .87 to .96 for concentric and eccentric values, respectively.

In addition to PTs, angle-specific torques (ASTs) potentially provide useful information about muscle function during rehabilitation. Assessment with ASTs may be particularly useful in the

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rehabilitation of injuries with strength deficits at specific points in the range of motion (e.g., muscle strains). However, as with PT, the usefulness of ASTs depends on their reliability. A few researchers have examined the reliability of ASTs. Bohannon and Smith (2) examined the intrasession reliability of concentric torque measurements taken at 30° and 45° and reported ICCs of .96 and .97 for each position, respectively. Kues et al. (10) also reported AST reliabilities along with their peak torque reliabilities. Their concentric ASTs at 40° and 60° ranged from .88 to .97, and their eccentric ASTs at 40° and 60° ranged from .89 to .97. More recently, Arnold et al. (1) used the Kin-Com's standard instrumentation to assess the reliability of concentric ASTs at 30°, 60°, and 75° and reported ICCs ranging from .83 to .87.

While each of these studies has examined a slightly different aspect of peak torque or AST reliability, none of the studies addressed the method of calculating peak torque or its effect on reliability. Tredinnick and Duncan (12) calculated peak torque by having the Kin-Corn software derive an average torque curve from three repetitions and then selected the highest value on the average torque curve. Harding et al. (5) used the same procedure as Tredinnick and Duncan except six repetitions were used to derive the average torque curve. Conversely, Bohannon and Smith (2) and Kues et al. (10) derived torque values by selecting the single highest value from four repetitions. Kramer (9) was unclear on how PT was calculated. Measurement theory (4) suggests that the average values of Tredinnick and Duncan (12) and Harding et al. (5) should be more reliable than the single best value used by Bohannon and Smith (2) and Kues et al. (10). However, Bohannon and Smith (2) and Kues et al. (10) reported higher ICCs, suggesting that their method of calculating peak torque may improve reliability.

The purpose of this study was to assess how four different methods of calculating peak torque and angle-specific torque affect peak torque and angle- specific torque reliability.

METHODS

Twelve university female students who were free of right knee injury (age = 21.8 ± 2.3 years, weight = 56.83 ± 12.91 kg, height = 166.57 ± 5.36 cm) gave informed consent to participate in the study.

Assessment

The measuring instrument was the Kinetic Communicator II isokinetic dynamometer with software version 2.31. The manufacturer's standard level arm and pad attachments for knee joint testing were used.

Data were collected by the same investigator on the right quadriceps muscle group with the subjects in the seated position. The axis of the dynamometer was aligned with the medial epicondyle of the femur, and Velcro straps were placed proximal to the malleoli, proximal to the knee, and across the hips for stabilization. The vertical and horizontal positions of the dynamometer were measured to ensure identical placement on the second test. Each repetition started at 90° of knee flexion and stopped at 10° of knee flexion. The speed of the dynamometer was set at 60° s-1. The force necessary to initiate motion of the dynamometer was set at 25 N and a minimal force needed to maintain motion was set at 20 N. Based on the findings of Hellwig and Perrin (6), gravity correction was performed with the knee in complete extension.

Subjects reported to the laboratory on two different occasions separated by approximately 48 hours. On each of the two different test sessions, the subjects warmed up on a stationary bicycle for 5 min. So subjects could become familiar with the protocol, each subject executed three submaximal followed by one maximal concentric and eccentric muscle contractions. After a 2-min rest, subjects executed five maximal concentric and eccentric contractions from which data were collected. Subjects paused briefly between each concentric and eccentric contraction to allow the data to be stored into memory.

Peak Torque Calculation and Extraction

For data analysis, the first three torque curves of each set of five contractions were averaged together, and the highest value of the average curve was identified as peak torque (average value). Additionally, each of the first three curves was examined separately, and the single highest value (best value) of the three was identified as peak torque. The same procedure was then applied using all five curves.

Angle-Specific Torque Calculation and Extraction

Angle-specific torques were calculated in the same manner as peak torque. The first three torque curves of each set of five contractions were averaged together, and the values at 30°, 60°, and 75° on the average curve were identified as the ASTs. Additionally, each of the first three curves was examined separately, and the single highest values of the three at 30°, 60°, and 75° were identified as ASTs. The same procedure was then applied using all five curves.

Statistical Analysis

ICCs were calculated from a repeated measures analysis of variance (ANOVA). Shrout and Fleiss's (11) formula (2,1) was used to calculate ICCs for the peak torques and ASTs extracted from single curves, and formula (2,k) was used to calculate ICCs for the peak torques and ASTs extracted from the average curves. Standard errors of the measure (SEM) were calculated by multiplying the standard deviation of the peak torques of each condition by the square root of 1-ICC. Additionally, a Fisher's Z transformation was performed on the R values, and a z test was performed between each three-repetition correlation coefficient and the corresponding five-repetition correlation coefficient.

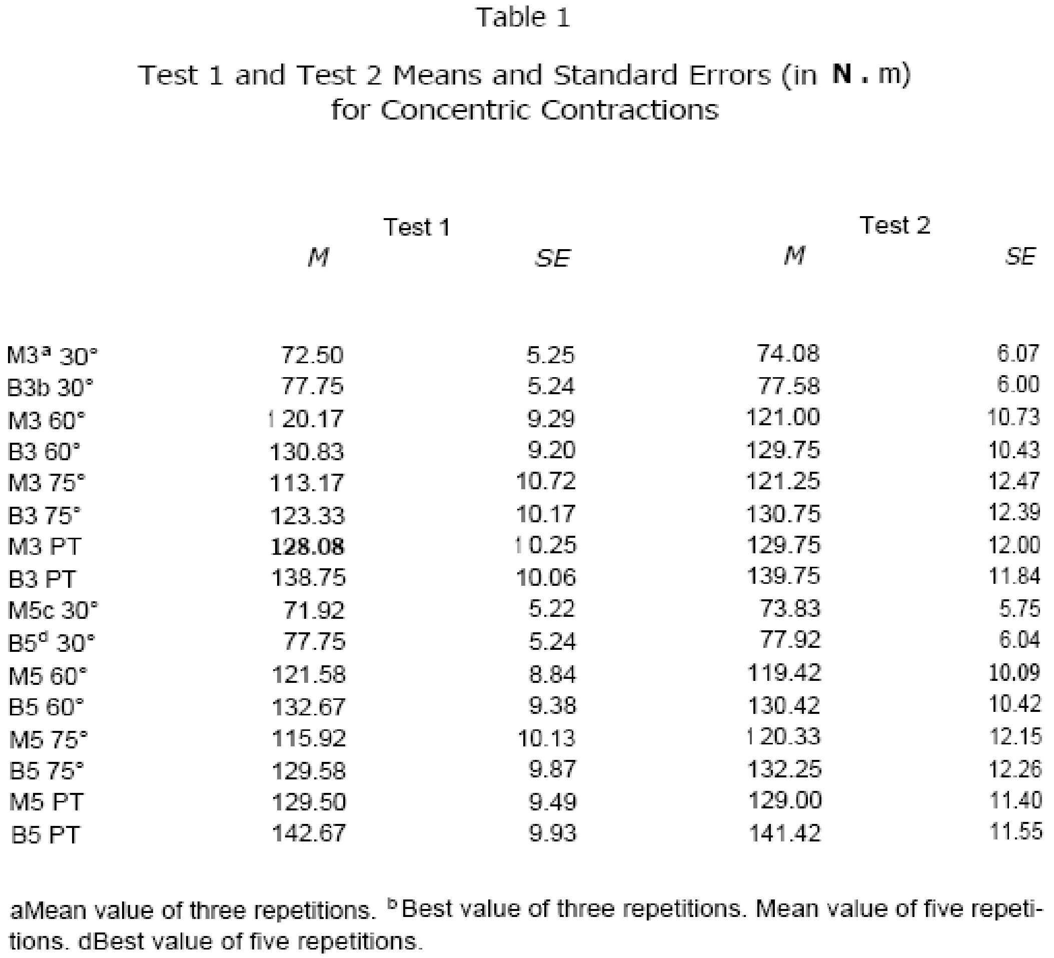

Table 1

Test 1 and Test 2 Means and Standard Errors (in **N .** m) for Concentric Contractions

	Test 1		Test 2	
	M	*SE*	*M*	*SE*
M3^a 30°	72.50	5.25	74.08	6.07
B3b 30°	77.75	5.24	77.58	6.00
M3 60°	120.17	9.29	121.00	10.73
B3 60°	130.83	9.20	129.75	10.43
M3 75°	113.17	10.72	121.25	12.47
B3 75°	123.33	10.17	130.75	12.39
M3 PT	**128.08**	10.25	129.75	12.00
B3 PT	138.75	10.06	139.75	11.84
M5c 30°	71.92	5.22	73.83	5.75
B5^d 30°	77.75	5.24	77.92	6.04
M5 60°	121.58	8.84	119.42	10.09
B5 60°	132.67	9.38	130.42	10.42
M5 75°	115.92	10.13	120.33	12.15
B5 75°	129.58	9.87	132.25	12.26
M5 PT	129.50	9.49	129.00	11.40
B5 PT	142.67	9.93	141.42	11.55

aMean value of three repetitions. ^{b}Best value of three repetitions. Mean value of five repetitions. dBest value of five repetitions.

RESULTS AND DISCUSSION

The Test 1 and Test 2 mean scores and standard errors of the means for all conditions are presented in Tables 1 and 2. The Test 1/Test 2 ICCs for concentric peak torque and angle-specific torques ranged from .89 to .97 with *SEMs* ranging from 3.59 N • m to 14.47 N • m (Table 3). For eccentric peak torque and angle- specific torques the ICCs ranged from .75 to .98 with *SEMs* ranging from 5.13 N • m to 17.31 N . m (Table 4). There were no statistical differences between any pairs of correlation coefficients.

The important finding in this study was that there were no significant differences in the ICCs among the four different methods of calculating quadriceps PT or AST. The quadriceps PT ICCs of this study are consistent with those found in previous studies (5, 9, 10) with the exception of Tredinnick and Duncan (12), thus supporting the conclusion that the different methods of calculating quadriceps PT had no effect on the reliability of the measures. At least two reasons may explain why the results of Tredinnick and Duncan (12) differ from results found by this and previous studies. First, Tredinnick and Duncan tested their subjects in the supine position rather than in the traditional seated position,

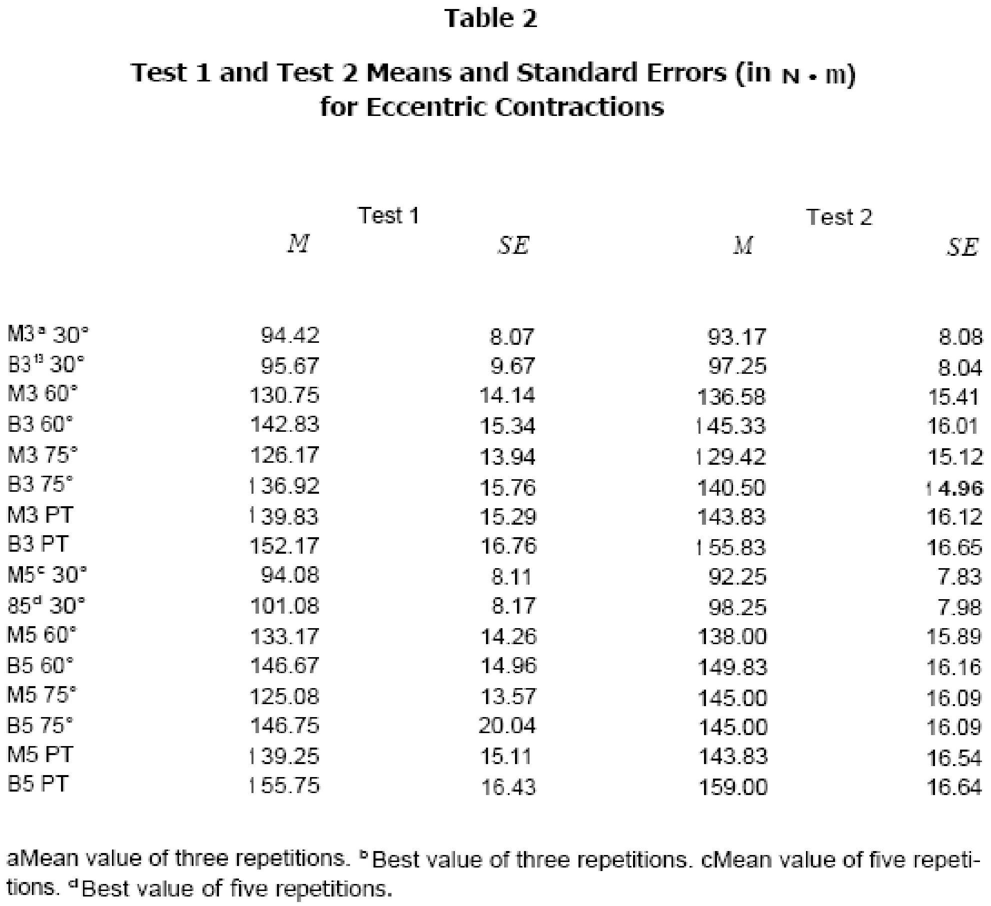

Table 2

Test 1 and Test 2 Means and Standard Errors (in N • m) for Eccentric Contractions

	Test 1		Test 2	
	M	*SE*	*M*	*SE*
M3^a 30°	94.42	8.07	93.17	8.08
B3^b 30°	95.67	9.67	97.25	8.04
M3 60°	130.75	14.14	136.58	15.41
B3 60°	142.83	15.34	145.33	16.01
M3 75°	126.17	13.94	129.42	15.12
B3 75°	136.92	15.76	140.50	14.96
M3 PT	139.83	15.29	143.83	16.12
B3 PT	152.17	16.76	155.83	16.65
M5^c 30°	94.08	8.11	92.25	7.83
85^d 30°	101.08	8.17	98.25	7.98
M5 60°	133.17	14.26	138.00	15.89
B5 60°	146.67	14.96	149.83	16.16
M5 75°	125.08	13.57	145.00	16.09
B5 75°	146.75	20.04	145.00	16.09
M5 PT	139.25	15.11	143.83	16.54
B5 PT	155.75	16.43	159.00	16.64

aMean value of three repetitions. ^{b}Best value of three repetitions. cMean value of five repetitions. ^{d}Best value of five repetitions.

and second the axis of the dynamometer was aligned inferior and posterior to the anatomical axis of the knee. Additionally, it is interesting to note that Kues et al. (10), using external hardware and software to achieve a higher sampling rate, reported ICCs for PT ranging from .94 to .98 and .87 to .96 for concentric and eccentric contractions, respectively. While several differences between our methods and those used by Kues et al. (10) (particularly differences in test velocity) render it difficult to draw direct comparisons between the studies, a comparison of their results with ours indicates that our values derived from torques calculated from five repetitions are well within these ranges. This may suggest that the higher sampling rate of 500 Hz, which is not available to clinicians, may not be necessary to obtain reliable measures. Additionally, it suggests that our quadriceps PT generated at a velocity of 60° • s' is just as reliable as Kues et al.'s (10) quadriceps PTs generated at 30°, 90°, and 120° •

Kannus and Kaplan (7) and Kannus and Yasuda (8) suggested that angle- specific torques are of less value than peak torque values in assessing muscle function because ASTs have higher coefficients of variation than do PTs. Our data suggest that use of the quadriceps AST may be similar in reliability to

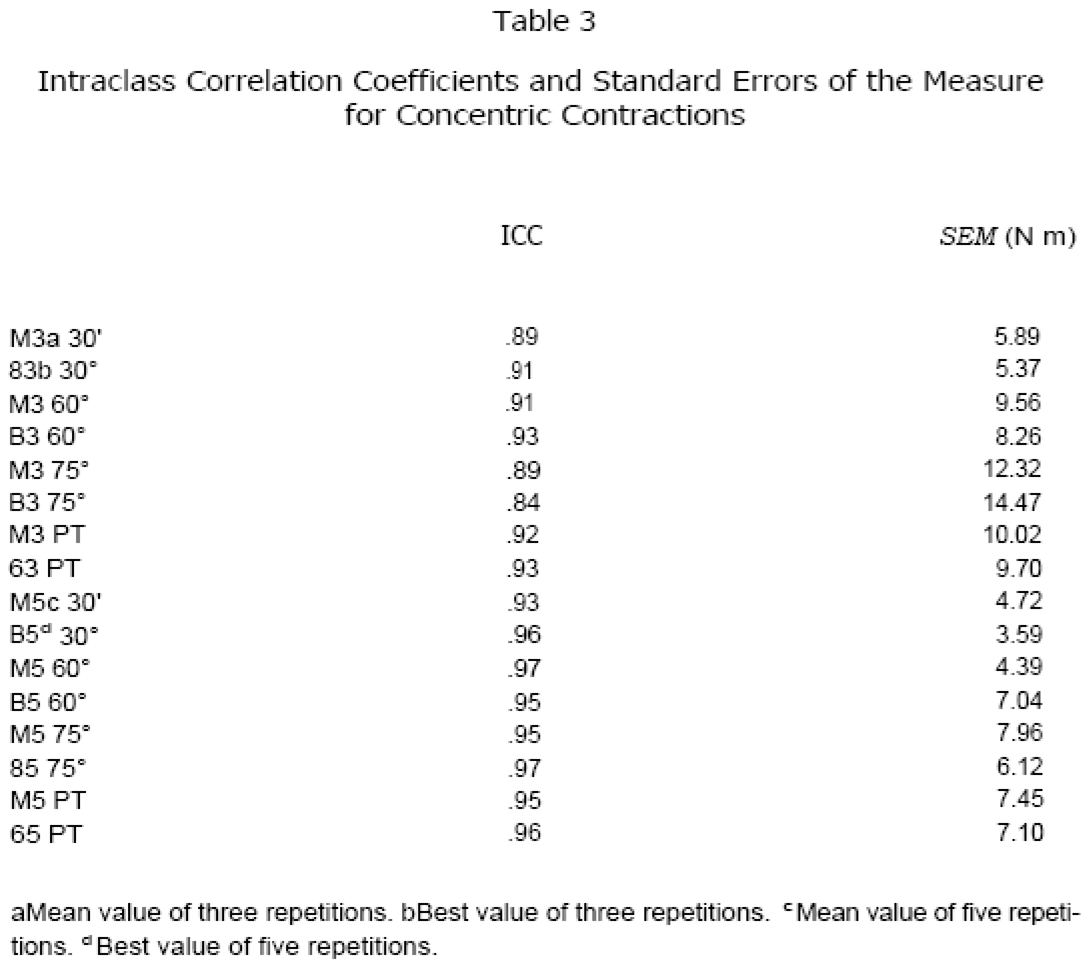

Table 3

Intraclass Correlation Coefficients and Standard Errors of the Measure for Concentric Contractions

	ICC	*SEM* (N m)
M3a 30'	.89	5.89
83b 30°	.91	5.37
M3 60°	.91	9.56
B3 60°	.93	8.26
M3 75°	.89	12.32
B3 75°	.84	14.47
M3 PT	.92	10.02
63 PT	.93	9.70
M5c 30'	.93	4.72
B5[d] 30°	.96	3.59
M5 60°	.97	4.39
B5 60°	.95	7.04
M5 75°	.95	7.96
85 75°	.97	6.12
M5 PT	.95	7.45
65 PT	.96	7.10

aMean value of three repetitions. bBest value of three repetitions. [c]Mean value of five repetitions. [d]Best value of five repetitions.

quadriceps PT. When best-value or average-value concentric AST ICCS or average-value eccentric AST ICCs are compared with their respective PT ICCs, the peak torque ICC is similar to the AST ICCs with concentric SEMs being either similar or lower for the angle-specific torques and eccentric SEMs being less for the ASTs. In contrast, the best-value eccentric five-repetition peak torque had a higher ICC than did any of the angle-specific torques calculated from the best value, and the SEMs for the ASTs were larger than the PT's SEM with the exception of the SEM of the 30° AST. Therefore, in contrast to Kannus and Kaplan (7) and Kannus and Yasuda (8) we believe that the quadriceps ASTs may be of similar value to quadriceps PT and thus may be useful to the clinician in assessing muscle function at specific points in the range of motion. Additionally, Kues et al. (10) reported ICCs for the AST at 60° ranging from .93 to .97 and .89 to .93 for concentric and eccentric values, respectively. Our values for concentric and eccentric ASTs at 60° are also within these ranges. Thus, as with PT the use of external instrumentation appears to be unnecessary to produce reliable ASTs, and it suggests that our ASTs generated at 60° • s' are just as reliable as Kues et al.'s (10) generated at 30°, 90°, and 120° •

In summary, our data indicate there is no difference among the four methods of calculating quadriceps PT and AST. Additionally, our data suggest that ASTs

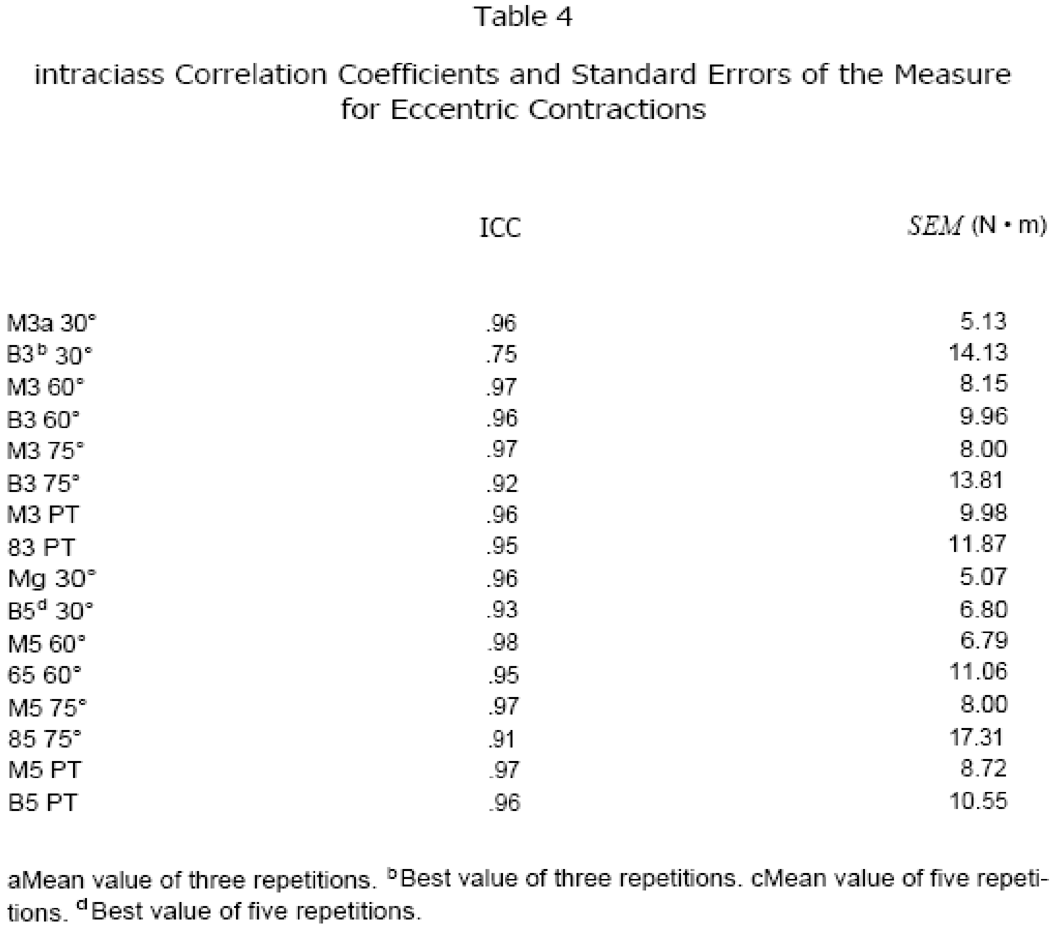

Table 4

Intraciass Correlation Coefficients and Standard Errors of the Measure for Eccentric Contractions

	ICC	SEM (N • m)
M3a 30°	.96	5.13
B3[b] 30°	.75	14.13
M3 60°	.97	8.15
B3 60°	.96	9.96
M3 75°	.97	8.00
B3 75°	.92	13.81
M3 PT	.96	9.98
83 PT	.95	11.87
Mg 30°	.96	5.07
B5[d] 30°	.93	6.80
M5 60°	.98	6.79
65 60°	.95	11.06
M5 75°	.97	8.00
85 75°	.91	17.31
M5 PT	.97	8.72
B5 PT	.96	10.55

aMean value of three repetitions. [b]Best value of three repetitions. cMean value of five repetitions. [d]Best value of five repetitions.

instrumentation used by Kues et al. (10) may not be necessary to obtain reliable PTs and ASTs.

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