Relationship Between Isokinetic Average Force, Peak Force, Average Torque, and Peak Torque of the Shoulder Internal and External Rotator Muscle Groups

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*****Note: Figures may be missing for this format of the document**

Abstract:

This study examined the relationship between concentric and eccentric average force, peak force, average torque, and peak torque of the shoulder internal and external rotator muscle groups in 33 male subjects. Testing of the nondominant side was accomplished with the shoulder at 90 degrees of abduction and the arm in the frontal plane. Peak values for both force and torque were obtained from the highest point in the strength curves, whereas average values were obtained across the entire curve. Correlation matrices found a relationship between the isokinetic parameters of r = 0.86 to 0.97 for concentric external rotation, r = 0.94 to 0.99 for eccentric external rotation, r = 0.86 to 0.96 for concentric internal rotation, and r = 0.55 to 0.97 for eccentric internal rotation. The strong relationship between average and peak force and torque suggests any of these isokinetic parameters may be used for assessment of human muscular performance. Factors that potentially confound the interchangeable use of these parameters include damp, ramp, preload, and the range of motion through which isokinetic assessment occurs.

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INTRODUCTION

Isokinetic dynamometry enables the rapid and reliable quantification of human muscular performance.[6] Most instruments measure the force produced by a muscle group from the axis of rotation of the dynamometer. The tension produced by the muscle is thus reported in the form of peak or average torque. If the force-sensing apparatus is located at the dynamometer's resistance pad as with the Kinetic Communicator (Kin Corn, Chattecx Corporation, Hixson, TN), the tension produced by the muscle is reported as a value of peak or average force. Knowledge of the distance of the resistance pad from the axis of rotation of the dynamometer enables conversion of the force value to either peak or average torque. Although most isokinetic studies report values of peak torque, others have reported strength in the form of average force[7,8,13] or average torque.[15]

In addition to force or torque, some isokinetic dynamometers also enable quantification of a muscle's capacity to generate work or power. Work is the product of the force and distance of a muscle contraction, and power is the time required to produce work, or force x distance/time.

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The Systeme International (SI) d'Unites is the preferred method of reporting values of force, torque, work, and power, and is presented (with conversions) in *Table 1*.

Table 1 Systeme International d'Unites (SI) units with conversions.

Force (Newton)	(lb) x 4.45 = (N)	(N) x 0.22 = (lb)
Torque (Newton meter)	(ft lb) x 1.36 = (Nm)	(Nm) x 0.4 = (ft lb)
Work (Joule)	(ft lb) x 0.74 = (J)	(J) x 1.36 = (ft lb)
Power (Watt)	(ft lbs/sec) x 1.36 = (W)	(W) x 0.74 = (ft lbs/sec)

The predictability of work and power from peak torque has been established in both healthy and injured populations.[2-4] However, the suitability of using peak and average force and torque measures interchangeably has not been determined. The purpose of this study was therefore to determine the relationship among concentric and eccentric peak and average force and torque of the shoulder rotator muscles in healthy subjects.

METHODS

Thirty-three men (age 20.09 years, height 180.49 cm, weight 78.99 kg) participated after giving their informed consent in accordance with institutional human subject investigational review board guidelines. Only subjects free from history or presence of injury to the nondominant shoulder girdle complex were allowed to participate in the study.

Isokinetic assessment of the nondominant side occurred from the seated position at 150 deg/sec through an 85-degree arc of motion (90 degrees external rotation to 5 degrees internal rotation) with the glenohumeral joint at 90 degrees of abduction and the arm positioned in the frontal plane. Subjects were secured with straps at the waist and chest, and their legs were extended forward and resting on a chair in a nonweight-bearing manner.

Before isokinetic assessment, gravity correction procedures were followed as described in a previous study.8 All subjects were provided a warmup session that consisted of five submaximal concentric and eccentric contractions of both the internal and external rotator muscle groups. After a brief rest period, a minimum of three maximal concentric and eccentric test contractions were performed by both muscle groups. Additional contractions were performed if needed to obtain three reproducible force curves using an overlay technique. A preload value of 25 N and a medium ramp setting were used for all test repetitions.

Table 2 Correlations between concentric shoulder internal rotation (IR) and external rotation (ER) peak force (PF), average force (AF), peak torque (PT), and average torque (AT).

	IRAF	ERAF	IRPF	ERPF	IRAT	ERAT
IRPF	0.90					
ERPF		0.91				
IRAT	0.96		0.88			
ERAT		0.97		0.90		
IRPT	0.86		0.95		0.92	
ERPT		0.86		0.96		0.92

Peak values of force were obtained from the highest point in the strength curve, and average values of force were obtained from across the entire curve for concentric and eccentric internal and external shoulder rotation. The distance of the resistance pad from the axis of rotation of the dynamometer was then used to convert the peak and average force values to peak and average torque. Correlation matrices were then generated to determine the relationship between the peak force, average force, peak torque, and average torque values.

RESULTS

The correlation coefficients between concentric and eccentric shoulder internal and external rotation peak force, average force, peak torque, and average torque are presented in *Tables 2* and *3*. The relationship between the concentric measures was consistently high, and ranged from 0.86 to 0.97. The correlations for the eccentric measures were also high (0.92 to 0.99), with the exception of the relationship between internal rotation peak torque and average force, peak force, and average torque (0.55 to 0.59).

Table 3 Correlations between eccentric shoulder internal rotation (IR) and external rotation (ER) peak force (PF), average force (AF), peak torque (PT), and average torque (AT).

	IRAF	ERAF	IRPF	ERPF	IRAT	ERAT
IRPF	0.97					
ERPF		0.99				
IRAT	0.96		0.92			
ERAT		0.96		0.96		
IRPT	0.55		0.59		0.56	
ERPT		0.94		0.96		0.99

DISCUSSION

The major finding of this investigation was that a strong relationship existed between most of the isokinetic measures of peak and average force and torque. This suggests that peak

torque, average torque, peak force, or average force are probably all valid isokinetic measures. However, several factors may confound the interchangeable use of peak and average force and torque. To account for the problem of isokinetic overshoot,[10] most isokinetic manufacturers have created either a damp, preload, and/or ramp feature. The use of damp effects assessment of peak torque1[1,12] and use of a static preload effects measurement of average force or torque·[1,5,14] As such, accurate isokinetic assessment necessitates consistency with respect to these features, and comparisons of average and peak values should be made cautiously when differences in damp, ramp, and preload settings exist in study methodology. Moreover, these factors may account for the difficulty in making intra- and intersubject comparisons of human muscular performance when assessment takes place on different isokinetic dynamometers.

The range of motion through which isokinetic assessment occurs may also confound comparisons of average and peak force or torque. Average force or torque is computed from all points along the entire force/torque curve. Assessment through a shorter arc of motion may eliminate lower points in the curve and thus produce a greater value of average force or torque. Because peak torque or force usually occurs in the midrange of joint motion, variations in range of motion probably do not have as pronounced an effect as when average force or torque is the parameter of interest. In cases where unilateral limitations in range of joint motion exist, peak torque or force may be the preferred parameter for isokinetic assessment. If average force or torque is to be used, consistency in range of motion, both with respect to test/retest and bilateral comparisons, is essential.

Evidence also exists that extremity dominance and the neuromuscular demands of sport performance may affect bilateral comparisons of human muscular performance.[9] The effect of these factors on comparisons of average and peak force and torque within single muscle groups is less clear, but may confound interchangeable comparisons of these isokinetic parameters. Our investigation assessed the shoulder internal and external rotators of the nondominant extremity in healthy male university students. Additional research should examine the relationship among average and peak force and torque of multiple muscle groups in a variety of athletic and nonathletic populations.

In summary, this investigation found a strong relationship among peak and average force and torque of the nondominant shoulder internal and external rotator muscle groups in healthy male subjects. An exception to this strong relationship was found for eccentric torque and force of the internal rotator muscle group. These findings suggest any of these isokinetic parameters are probably valid measures, although several factors potentially confound the interchangeable use of peak and average force and torque. Further research should examine the relationship among these isokinetic parameters in a variety of muscle groups in both athletic, nonathletic, healthy, and injured populations.

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