REPRODUCIBILITY OF CONCENTRIC AND ECCENTRIC PEAK TORQUE IN FEMALES

Barbara L. Warren

University of Puget Sound, Tacoma, WA, USA

The purpose of this study was to assess the ability of female subjects to reproduce peak torque during concentric and eccentric muscle contractions as measured by a CYBEX NORM isokinetic dynamometer. Twenty female subjects were tested using a knee extension protocol (both concentric and eccentric) at velocities of 60 and 120 deg/sec with a 30 sec rest between each repetition and a 1 min rest between velocity sets. ANOVA results indicated a significant interaction between velocity and order effect (4.47, $p<.05$). Pearson correlations were found to be significant for all velocities, with the eccentric first group producing overall higher correlation coefficients. In this study the subjects who performed eccentric tests initially were more consistent in reproducing peak torque.

KEY WORDS: isokinetic, peak torque

INTRODUCTION: Over the years many isokinetic studies have measured the reproducibility or reliability of data produced using particular dynamometers (Adsuar, Olivares, pozo-Cruz, Paraca, & Gusi 2011; Bardis, Kalamara, Loucaides, Michaelides & Tsaklis, 2004; Cotte & Ferret, 2003; Dirnberger, Kosters & Muller, 2012; Li, Wu, Maffulli, Chan & Chan, 1996; Maffiuletti, Bizzini, Desbrosses, Babault & Munzinger, 2007; Orri & Darden, 2008; Sole, Hamren, Milosavljevic, Nicholson & Sullivan, 2007). In most cases the dynamometers have been found to provide reproducible data. Furthermore, almost all data have been collected using the knee flexion and extension motion and most often with a concentric protocol.
Most recently, a study by Dirnberger et al. (2012) examined the reproducibility of peak torque in male subjects while using an IsoMed 2000 dynamometer. The subjects performed either a concentric then eccentric protocol or an eccentric then concentric protocol. The subjects were tested on three occasions, without the benefit of a familiarization session. Dirnberger et al. (2012) reported reproducible results for all tests, but that stronger reproducibility was found in concentric tests than those in eccentric tests. However, there has been little data investigating reproducibility of peak torque in the female population.
The hypothesis of this study was that females would have reproducible peak torque regardless of the order of executing concentric or eccentric velocity sets.

METHODS: Twenty college-aged females from the University of Puget Sound were recruited to participate in the study and were tested four times. Prior to participation, each subject signed an informed consent that was approved by the IRB at the University of Puget Sound. The means and standard deviations of the demographic information were as follows: age 21.2 ± 1.1 years, height 166.7 ± 7.5 cm and mass 66.2 ± 7.7 kg. The strength of the knee extensors of the right leg was measured using a CYBEX NORM isokinetic dynamometer (CYBEX). Before each testing session, subjects performed a 5-minute warm-up on a cycle ergometer at a self-selected pace. Prior to experimental data collection, subjects were familiarized with the CYBEX on one occasion. Subjects were fitted into the CYBEX according to the manufacturer's protocols, including gravity correction and given verbal instructions prior to beginning the test. The CYBEX warmup consisted of 4 sub-maximal knee extensions at four sets of velocities in the following order: concentric 60 deg/sec, concentric 120 deg/sec, eccentric 60 deg/sec and eccentric 120 deg/sec. Between each repetition there was a 30 sec rest and between each velocity set there was a 60 sec rest. After completing the CYBEX warm up, each subject completed a maximal knee extension protocol of five repetitions at each of the four velocity sets using one of the

randomly assigned velocity orders: concentric 60 deg/sec, concentric 120 deg/sec, eccentric 60 deg/sec, and eccentric 120 deg/sec or eccentric 60 deg/sec, eccentric 120 deg/sec, concentric 60 deg/sec, and concentric 120 deg/sec. The rest protocol was the same as that used during the warmup. All subjects were tested with a minimum 24 hour rest between data collection sessions. Subjects were given both verbal encouragement and visual feedback during the warmup and experimental trials. This same protocol was used for all testing sessions and data were not normalized. Data were analyzed using 2 (order) X 3 (test days) X 4 (velocity) repeated measures ANOVA ($\alpha < .05$) to assess differences in peak torque. Additionally, Pearson correlations ($\alpha < .05$) were computed to assess consistency of peak torque between testing days.

RESULTS and DISCUSSION: The hypothesis of this study was that females would have reproducible peak torque regardless of the order of executing concentric or eccentric velocity sets. This hypothesis was accepted as indicated from the results presented below.
The Pearson correlations for both the concentric first group (CF) and the eccentric first group (EF) are found in Table 1. In the CF group the results indicated there were three correlations that were an r = 0.9 or above. Concentric peak torques at 60 deg/sec test two-three, and tests one-two and two-three for concentric comparisions at 120 deg/sec. However, there were no strong correlations in the CF group when comparing eccentric peak torque. This is a departure from the results of Dirnberger et al. (2012) in which the male subjects, regardless of order of testing, all produced torques with a correlation of r = 0.9 or above. From observing the data presented in Figure 1, it is easy to establish that the CF group was more consistent in reproducing peak torque when executing the concentric protocol than they were with the eccentric protocol.

Table 1. Correlation coefficients of peak torque by test days and protocols.

	CF		EF	
	Concentric- Eccentric		Eccentric-Concentric	
	T1-T2	T2-T3	T1-T2	T2-T3
CON				
60 deg/sec	r = 0.690	r = 0.945	r = 0.916	r = 0.901
120 deg/sec	r = 0.967	r = 0.985	r = 0.824	r = 0.874
ECC				
60 deg/sec	r = 0.798	r = 0.759	r = 0.868	r = 0.835
120 deg/sec	r = 0.794	r = 0.877	r = 0.909	r = 0.906

All correlations were significant at $p < .05$

The EF group produced four correlations of peak torque that were above r = 0.9. Correlations of concentric 60 deg/sec for tests one-two and two-three and eccentric 120 deg/sec for tests one-two and tests two-three. The remaining correlations ranged from r = 0.618 - 0.882. When observing Figure 2, it is easy to observe that the EF group was more consistent in producing peak torque at all velocities. The reproducibility findings at the 120 deg/sec peak torques are consistent with what Li et al. (1996) previously reported, while those at 60 deg/sec concentric peak torques support the work of Dirnberger et al. (2012).
In both Figures 1 and 2 the familiarization day results were included to observe any learning effect that might have taken place. In Dirnberger et al. (2012) there had been no familiarization day for the subjects and they suggested that this be added when testing subjects unfamiliar with an isokinetic dynamometer. Looking at Figures 1 and 2 it is evident that with one exception subjects improved from the familiarization day to subsequent days of testing, regardless of order, which indicates it would be wise to include familiarization days prior to experimental tests.

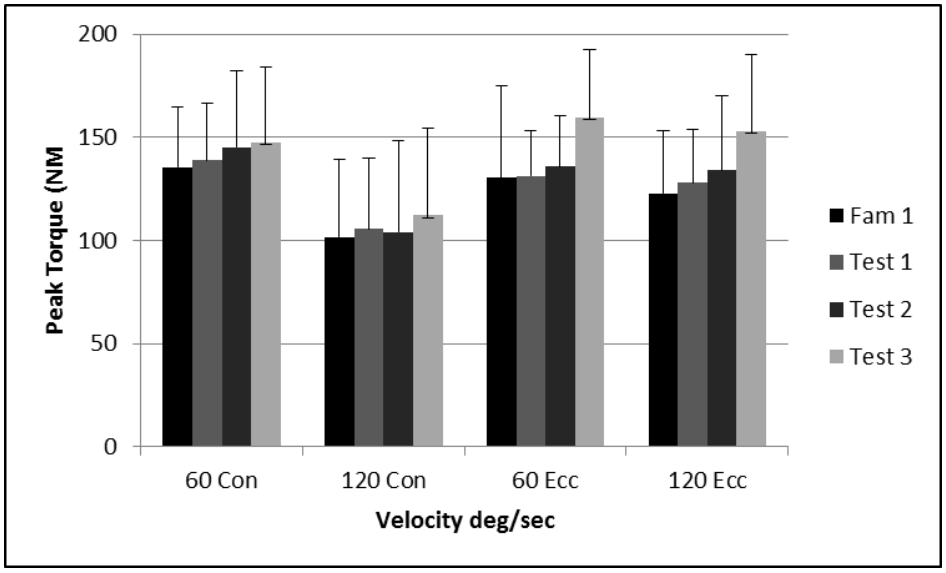

Figure 1: Means and standard deviations of peak torque for CF group. (N=9)

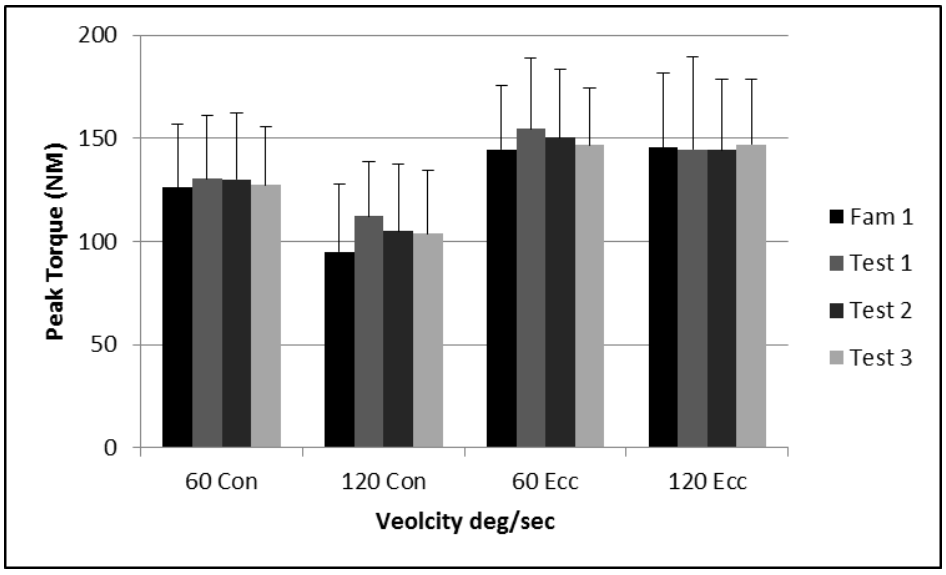

Figure 2: Means and standard deviations of peak torque for EF group. (N=11)

The ANOVA results indicated there was a significant interaction effect of order of testing and velocity. The EF group produced more consistent peak torque within each velocity set and certainly greater peak torques for eccentric velocity sets initially. The CF group seemed to improve peak torque with each day of testing, as well as producing greater peak torques for concentric velocity sets throughout most testing days. These results reinforce the idea that when using both concentric and eccentric protocols with the concentric contractions first, it would be prudent to provide several practice sessions of the eccentric protocol prior to

experimental data collection. If using eccentric velocity sets initially one might expect the concentric peak torques to be consistently lower, at least in females.

CONCLUSION: In this study the EF group was able to reproduce peak torque more consistently than the CF group. This would be important for practitioners to consider when they are using isokinetic testing to indicate progress in rehabilitation, as a prescreening tool, or as a method to identify injury potential. Further research should consider whether using eccentric velocity sets initially during experimental testing is of significant value.

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