Effect of repeated isokinetic concentric and eccentric contractions on quadriceps femoris muscle fatigue

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Abstract:
Using the Kin-Com (Chattecx Corp, Hixson, TN) isokinetic dynamometer, 20 university females (age = 21.6 ± 1.4 years, wt = 61.73 ± 7.3 kg, ht = 162.81 ± 5.8 cm) performed concentric and eccentric isokinetic contractions at nine different velocities. At each velocity, subjects performed two submaximal and one maximal concentric and eccentric familiarization contractions. Three alternating concentric and eccentric maximal contractions followed a 1-min rest between the familiarization and maximal contractions. One minute of rest was also provided between the test contractions and the next set of familiarization contractions. The peak torque (PT) and average torque (AT) for the first and ninth set of contractions were analyzed with separate repeated measures ANOVAs. The results demonstrated no significant differences for the interaction or for the test main effect for either PT or AT. This suggests that with appropriate rest intervals, as many as 96 submaximal and maximal concentric and eccentric contractions can be performed without fatigue affecting assessment of PT and AT.

Article:

1.INTRODUCTION

Perrine and Edgerton [8] established that the force of isokinetic concentric torque increases as velocity decreases. Conversely, in a recent study by Arnold et al. [1], it was determined that isokinetic eccentric muscular torque increases as velocity increases. These studies suggest that it is necessary to perform multiple velocity testing to fully assess muscular performance.

One of the concerns with multiple velocity testing is the potential impact of fatigue on the results. Nilsson et al. [7] found that with moderate speed isokinetic contractions, quadriceps concentric peak torque declined 45-50% after 50 contractions. Similarly, Komi and Rusko [3] demonstrated that with slow isokinetic contractions, biceps brachii eccentric and concentric peak torques decreased by 18-20% and 50%, respectively. Finally, Gray and Chandler [2] produced results similar to Nilsson et al. [7] for concentric quadriceps contractions at 180°/s but reported no change in eccentric peak torque after 40 repetitions, thus contradicting the results of Komi and Rusko [3].

One of the obvious problems with these studies is contractions were performed at only one velocity and thus fail to assess the impact of multiple-velocity testing on fatigue. Kovaleski et al. [6] and Kovaleski and Heitman [4,5] examined the impact of fatigue using a multiple velocity (i.e. 30, 90, 150, 210°/s) rehabilitation protocol. Specifically, Kovaleski et al. [6] reported that

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when slow velocities were used initially, concentric isokinetic average power was significantly less than that produced by protocols using fast velocities initially. Similarly, in a study using an identical protocol, Kovaleski and Heitman [4] demonstrated that both average torque and average power significantly declined with protocols starting with slow velocities. However, in a third study using the same protocol, Kovaleski and Heitman [5] reported no differences for peak torque.

As mentioned above, the Kovaleski studies [4--6] were designed to examine rehabilitation protocols, not isokinetic assessment protocols. Specifically, subjects performed 20 consecutive repetitions at each velocity. This is much greater than the number of contractions typically used for isokinetic assessment. Furthermore, neither of the studies examined the effects of eccentric contractions on fatigue. Thus, the purpose of our study was to examine the effects of a typical multiple velocity assessment protocol on concentric and eccentric quadriceps fatigue.

2. METHODS

2.1. *Subjects*

Twenty females (age = 21 ± 1.4 years, ht = 162.81 ± 5.8 cm, wt = 61.73 ± 7.3 kg) with no training experience or knee pathology gave informed consent to participate in the study.

2.2. *Dynamometer set-up*

Each subject sat on the Kin-Com II isokinetic dynamometer (Chattecx Corp., Hixson, TN) with the lateral epicondyle of the knee aligned with the axis of the dynamometer, and the force pad attached to the tibia. Velcro straps were placed across the hips, thigh and ankle of each subject for stabilization.

2.3. *Test protocol*

Prior to testing, subjects were asked to kick a tennis ball, and the opposite leg of the one used to kick the ball was used for testing. Subjects were randomly assigned to one of eight velocity orders (Table 1) and performed concentric and eccentric contractions at 25, 50, 75, 100, 125, 150, 175, and 200°/s, with the original velocity repeated for the ninth test velocity. For warm up, subjects performed a 5-min exercise bout on a stationary cycle. At each velocity, subjects performed two submaximal and one maximal concentric and eccentric contraction for familiarization followed by three alternating concentric and eccentric maximal contractions. The eccentric test contraction at a given velocity immediately followed the concentric test contraction at the same velocity without any rest between the contractions. A 1-min rest was given between the familiarization contractions and the maximal contractions and between the maximal contractions and the next set of familiarization contractions. Gravity correction was performed with the knee at 0 degrees of flexion with the preload and minimal force values set at 50 and 20 N, respectively. All contractions were performed through 10-100 degrees of flexion.

2.4. *Data extraction and analysis*

Peak torque (PT) and average torque (AT) were collected from the three maximal contractions of the first (test 1) and ninth (test 9) set of contractions. PT was identified as the highest value on the mean curve of the three maximal contractions, and AT was identified as the mean torque of the mean curve. A separate repeated measures ANOVA with two crossed within factors (type of contraction by test) was per:. formed for PT and AT. When necessary, a Tukey post hoc analysis was performed. The alpha level for all tests was set at 0.05.

3. RESULTS

The concentric and eccentric average torque and peak torque means for test 1 and test 9 are presented in Table 2. The ANOVA demonstrated no significant differences for the interaction ($F = 0.63$, d.f. = 1,19 and $F = 0.02$, d.f. = 1,19) (Fig. 1 and Fig. 2), or for the test main effect ($F = 0.02$, d.f. = 1,19 and $F = 1.86$, d.f. = 1,19), for either PT or AT, respectively. As expected, there was a significant difference for the contraction main effect for PT ($F = 36.83$, d.f. = 1,19) and AT ($F = 73.73$, d.f. = 1,19).

Table 1
Velocity counterbalancing

Subject	Velocity							
1	25	50	75	100	125	150	175	200
2	200	25	50	75	100	125	150	175
3	175	200	25	50	75	100	125	150
4	150	175	200	25	50	75	100	125
5	125	150	175	200	25	50	75	100
6	100	125	150	175	200	25	50	75
7	75	100	125	150	175	200	25	50
8	50	75	100	125	150	175	200	25

Table 2
Concentric and eccentric means and standard deviations for average and peak torque

	Concentric		Eccentric	
	Test 1	Test 9	Test 1	Test 9
Average Torque (Nm)	58.95 (18.96)	57.15 (16.91)	76.85 (18.53)	74.65 (20.46)
Peak Torque (Nm)	81.50 (25.01)	80.15 (22.80)	103.75 (26.16)	102.60 (24.38)

4. DISCUSSION

The major finding of this study was that the assessment protocol used in this study did not produce fatigue. Specifically, these data suggest that with appropriate rest intervals, as many as 96 submaximal and maximal concentric and eccentric contractions can be performed in one test session without fatigue adversely affecting peak and average torque measures.

Comparison of our findings with other studies is difficult due to large differences in methodologies. For example, Nilsson et al. [7], Komi and Rusko [3], and Gray and Chandler [2] had subjects perform 40 or more continuous contractions. Thus, these tests were specifically intended to produce fatigue so the amount of fatigue could be documented.

The protocols of Kovaleski et al. [6] and Kovaleski and Heitman [4,5] are closer to our study, although, major differences still exist. For example, the intent of both of Kovaleski's studies was to assess the impact of fatigue on multiple velocity rehabilitation protocols. Their subjects performed 20 contractions at each velocity rather than three to five contractions that are typically used in assessment purposes. Thus, it is possible that the fatigue effects reported in Kovaleski's studies are due to the large number of contractions performed at each velocity. Additionally, with the exception of average and peak torque, the dependent measures of our study are not the same as those used by Kovaleski. Specifically, Kovaleski et al. [6] examined average power and total work, Kovaleski and Heitman [4] examined average power and average torque, and Kovaleski and Heitman [5] examined peak torque, average torque, and average peak torque. Thus, it is possible that the differences are partially due to differences among the dependent measures. Despite these protocol differences, their results do suggest that fatigue may impact multiple velocity endurance assessments.

We believe two basic factors may have prevented the expected decline in torque production. First, as stated above, only 12 total contractions (two submaximal and four maximal concentric and eccentric contractions) were performed at each velocity rather than 20 maximal contractions. The second basic factor is the 1-min rest intervals utilized. In Kovaleski's studies [4--6] a 1-min rest interval was used. However, these occurred only after every 20 contractions compared to after every six contractions in our study. Thus, it is possible that the increased frequency and increased total time of the rest intervals may have prevented the development of fatigue.

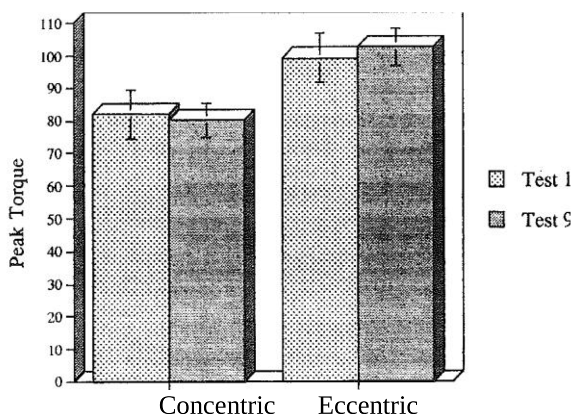

Fig. 1. Concentric and eccentric peak torque (Nm) means and standard errors.

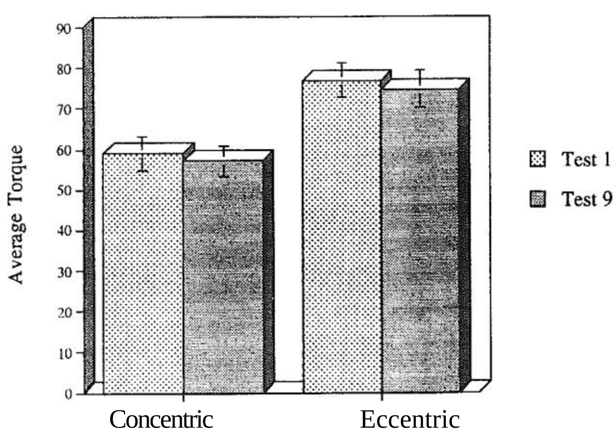

Fig. 2. Concentric and eccentric average torque (Nm) means and standard errors.

In conclusion, our protocol appears to prevent the development of fatigue when as many as 96 submaximal and maximal concentric and eccentric contractions are performed. Thus, by using this protocol the clinician may perform multiple velocity isokinetic testing without concern of fatigue impacting the peak torque and average torque of velocities performed late in the protocol.

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