

Research article

THE EFFECTS OF REST INTERVAL ON QUADRICEPS TORQUE DURING AN ISOKINETIC TESTING PROTOCOL IN ELDERLY

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ABSTRACT

The purpose of this study was to compare three different intervals for a between sets rest period during a common isokinetic knee extension strength-testing protocol of twenty older Brazilian men (66.30 ± 3.92 yrs). The volunteers underwent unilateral knee extension (Biodex System 3) testing to determine their individual isokinetic peak torque at 60, 90, and $120^{\circ}\cdot\text{s}^{-1}$. The contraction speeds and the rest periods between sets (30, 60 and 90 s) were randomly performed in three different days with a minimum rest period of 48 hours. Significant differences between and within sets were analyzed using a One Way Analysis of Variance (ANOVA) with repeated measures. Although, at angular velocity of $60^{\circ}\cdot\text{s}^{-1}$ produced a higher peak torque, there were no significant differences in peak torque among any of the rest periods. Likewise, there were no significant differences between mean peak torque among all resting periods (30, 60 and 90s) at angular velocities of 90 and $120^{\circ}\cdot\text{s}^{-1}$. The results showed that during a common isokinetic strength testing protocol a between set rest period of at least 30 s is sufficient for recovery before the next test set in older men.

KEY WORDS: Aging, muscle strength, muscle fatigue, isokinetic test.

INTRODUCTION

It has been well documented that the force generating capacity of human muscle declines with increasing age, especially after the age of 60 (Fronteira et al., 1991; Hakkinen et al. 1998; Larsson 1978; Lexell, 1995). This has been attributed to a reduced voluntary activation (Bilodeau, 2001) and, to a great extent, to a reduction in muscle mass (Proctor et al., 1998), associated with alterations in hormone balance (Hakkinen and Pakarinen, 1993) and quantity and intensity of physical activity (Mälkiä et al., 1994).

The assessment of muscular strength is essential for understanding the performance

capacity of an older individual. Muscular strength is a valuable attribute to perform many simple day-to-day activities, such as carrying groceries or walking a flight of stairs. Thus, there is a need for a reliable and accurate assessment of muscular performance parameters to determine an older individual's capabilities and potential limitations (Thompson and Bembem, 1999).

The development of isokinetics dynamometers has instigated considerable research on the vivo characteristics of human muscles (Kannus, 1992; Ostering, 1986). At the same time, commercially available isokinetics machines have created lots of clinical application for injury rehabilitation, measurements of muscular torque,

work, power, or endurance. In addition, whole-muscle function testing in human subjects is a widely used criterion measure to characterize and/or evaluate different populations. However, many internal and external factors in the isokinetic testing procedures can have an undesirable effect on the test results (Kannus, 1994). One factor would be the period of time between sets of isokinetics testing.

According to Parcell (2002), rest times between intrasession rest intervals reported in the literature range from 30 s to 3 min in length, and in many cases studies fail to report between sets rest interval times. Furthermore, in the same study, Parcell (2002) using college-age men, reported that 60 s between set rest period is sufficient for recovery before the next test set. However, Woods et al. (2004) reported that interset rest interval length between 2 and 4 minutes is ideal for minimizing muscle fatigue. Thus, it is clear that there is not a consensus with regard to between sets recovery periods during isokinetic testing, as well as, a lack of these types of studies in elderly population. It was the purpose of this study to compare three different interset rest periods during a common isokinetic leg extension strength-testing protocol.

METHODS

Subjects

This study was approved by the Institutional Review Board of the Catholic University of Brasilia in Brazil. Twenty older men from the Brasilia area, between the ages of 60 and 74 years, participated in the study on a volunteer basis. The men were selected at random from the respondents to fliers distributed to health clubs, social clubs, public offices, and by word-of-mouth. The volunteers were informed of the purpose, procedures, possible discomforts, risks, and benefits of the study prior to giving an informed written consent. The participants were excluded from the study if they had not reported history of cardiovascular disease, hypertension, or orthopedic disease.

The subjects were instructed not to eat within four hours, drink alcohol within 48 hours, or exercise within 24 hours prior to arrival at the laboratory. Upon arrival, all participants gave written informed consent and filled out the questionnaires. Succeeding the tests, the participants received oral and written interpretations of the results.

Experimental procedures

To test the effect of rest period length on isokinetic knee extensor torque, subjects performed a standard isokinetic protocol on three separate days with at least 48 hours between test sessions. The volunteers performed two sets of four repetitions isokinetic contraction at $60^{\circ}\cdot\text{s}^{-1}$, $90^{\circ}\cdot\text{s}^{-1}$ and $120^{\circ}\cdot\text{s}^{-1}$ at each of the three visits with the interset rest interval (30, 60, 90 s) varying between visits. The order of the rest period conditions and the contraction velocities were counterbalanced.

Warm up and familiarization

A standard cycling and knee extension warm-up protocol was performed. Subjects exercised on a cycle ergometer at 25-50 Watts for 5 min. After the cycle warm-up, subjects were seated on the isokinetic dynamometer and actively warmed-up the involved quadriceps muscles by performing ten to twelve submaximal knee extension repetitions at $300^{\circ}\cdot\text{s}^{-1}$.

Measurement of isokinetics torque

Isokinetic peak torque was measured on the Biodex system III Isokinetic Dynamometer (Biodex Medical, Inc., Shirley, NY). The volunteered sat upright with the axis of rotation of the dynamometer arm oriented with the axis of rotation of the right knee. Belts were used to secure the thigh, pelvis, and trunk to the dynamometer chair to prevent additional body movement. The chair and dynamometer settings were recorded to ensure the same positioning for all three of the experimental tests. The lateral femoral epicondyle was used as the bony landmark for matching the knee joint with the axis of rotation of the dynamometer resistance adapter. Gravity correction was obtained by measuring the torque exerted on the dynamometer resistance adapter with the knee in a relaxed state at full extension. Subjects were instructed to fully extend and flex the knee and to work maximally during each set of exercises. Strong verbal encouragement was given throughout the test session. After each set, subjects were required to take 30, 60, or 90 s of rest before the onset of the next set. The knee strap was released during each rest period to ensure unrestricted blood flow to the quadriceps. The procedures were administered to all subjects by the same investigator. Calibration of the Biodex dynamometer was performed according to the manufacturer's specifications before every testing session.

Statistical analyses

Statistical evaluation of the data was measured using a 3 x 3 repeated measures analysis of variance [time (pre and post rest interval) x rest

interval (30, 60, and 90 s) x velocity (60, 90, and $120^{\circ}\cdot\text{s}^{-1}$) with a Least-significant difference (LSD) *post-hoc* procedure for all peak torque measurements. The probability level of statistical significance was set at $p < 0.05$ in all comparisons. All data were entered into a personal computer and statistical procedures performed using the SPSS statistical package (v. 10.0). Descriptive statistics were expressed as means (\pm SD).

RESULTS

The physical characteristics of the participants ($n = 20$) are presented in Table 1. Initial screening of the data revealed that all variables were normally distributed, and no statistical outliers were found ($Z < \pm 3.29$). Therefore, all subjects were included in the subsequent analyses.

Table 1. Physical characteristics of the sample ($n=20$).

Variables	Mean (\pm SD)	Range
Age (years)	66.3 (3.9)	60 - 74
Height (m)	1.65 (.06)	1.51 - 1.79
Body mass (kg)	73.0 (10.7)	57.4 - 90.0
Body Fat (%)	17.4 (3.2)	10.4 - 21.7

Initial analysis of the data revealed no significant ($p > 0.05$) interaction on peak torque effect between rest periods and knee extension velocity. In addition, no significant rest period main effect ($p > 0.05$) was observed. However, there was a significant difference ($p < 0.05$) on peak torque main effect among all velocities (Figure 1).

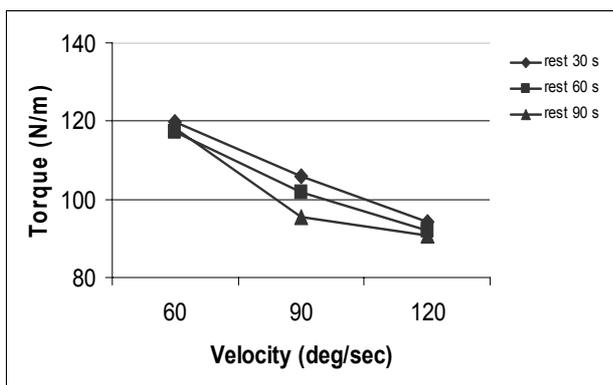


Figure 1. Mean knee extension torque-velocity curves.

Since there was no interaction effect, the main effect of intersit rest conditions was analyzed independently. Results of the knee extension peak torque at $60^{\circ}\cdot\text{s}^{-1}$ are presented in Table 2. Results revealed no significant peak

torque differences between first and second set at 30, 60, and 90 s rest interval.

Table 3 demonstrate the results of the knee extension peak torque at $90^{\circ}\cdot\text{s}^{-1}$. Results revealed no significant peak torque differences between first and second set at 30, 60, and 90 s rest interval.

Table 2. Results of the knee extension peak torque (N/m) at $60^{\circ}\cdot\text{s}^{-1}$ ($n=20$).

Variables	Mean (\pm SD)	Δ
PT1-30 s	116.3 (28.9)	
PT2-30 s	119.8 (27.3)	3.45
PT1-60 s	117.2 (29.2)	
PT2-60 s	116.3 (28.3)	.85
PT1-90 s	117.2 (28.0)	
PT2-90 s	118.1 (29.1)	.90

PT1 = peak torque 1st set; PT2 = peak torque 2nd set; 30s = 30s rest interval; 60s = 60s rest interval; 90s = 90s rest interval; $\Delta = \text{PT1-PT2}$.

Table 4 demonstrate the results of the knee extension peak torque at $120^{\circ}\cdot\text{s}^{-1}$. Results revealed no significant peak torque differences between first and second set at 30, 60, and 90 s rest interval.

Table 3. Results of the knee extension peak torque (N/m) at $90^{\circ}\cdot\text{s}^{-1}$ ($n=20$).

Variables	Mean (\pm SD)	Δ
PT1-30 s	98.8 (25.0)	
PT2-30 s	106.0 (25.0)	7.15
PT1-60 s	98.5 (25.9)	
PT2-60 s	101.9 (26.2)	3.35
PT1-90 s	95.6 (29.3)	
PT2-90 s	94.9 (30.2)	5.80

PT1 = peak torque 1st set; PT2 = peak torque 2nd set; 30s = 30s rest interval; 60s = 60s rest interval; 90s = 90s rest interval; $\Delta = \text{PT1-PT2}$.

DISCUSSION

The main findings of this study demonstrated no significant differences in torque production at any velocity among the 30, 60 and 90 s rest period trials. A protocol consisting of four successive maximal contractions at three velocities ($60^{\circ}\cdot\text{s}^{-1}$, $90^{\circ}\cdot\text{s}^{-1}$ and $120^{\circ}\cdot\text{s}^{-1}$) administered in a random order. This protocol was selected due to its similarity to isokinetic strength-testing protocols generally described in the literature (Parcell et al. 2002). The results of the present study showed a significant decline in peak torque with increasing

velocities. These results suggested that the great decline in torque during subsequent exercise at high velocity could be due to great exhaustion of fatigue sensitive type II fibers, whereas low velocity subsequent exercise is less affected because of the great use of type I fibers (Spendiff and Longford, 2002).

Table 4. Results of the knee extension peak torque (N/m) at $120^{\circ}\cdot\text{s}^{-1}$ (n=20).

Variables	Mean (\pm SD)	Δ
PT1-30 s	89.0 (20.0)	
PT2-30 s	94.1 (21.0)	5.15
PT1-60 s	86.8 (20.9)	
PT2-60 s	91.9 (22.6)	5.15
PT1-90 s	84.1 (24.9)	
PT2-90 s	90.8 (24.8)	6.75

PT1 = peak torque 1st set; PT2 = peak torque 2nd set; 30s = 30s rest interval; 60s = 60s rest interval; 90s = 90s rest interval; Δ = PT1-PT2.

The findings of the present study, however, appear to be contrary to others reported in the literature. Pincivero et al. (1998) reported a significant reduction in isokinetic concentric quadriceps peak torque when a 40 s interset rest interval was applied to a four sets of 10 repetitions at $90^{\circ}\cdot\text{s}^{-1}$. In a subsequent study, Pinciveiro et al. (1999) also found a significant reduction in isokinetic peak torque when a 40 s between sets rest interval was used as compared to 160 s rest interval, during four sets of 20 repetitions at $180^{\circ}\cdot\text{s}^{-1}$. Touey et al. (1994) also reported a significant decline of peak torque at 30 and 60 s interset rest interval when completed four sets of 10 maximal isokinetic quadriceps contractions at either 60 or $180^{\circ}\cdot\text{s}^{-1}$.

Followed by a 3 sets of 30 repetitions, Bilcheck et al. (1993) also administered an isokinetics strength testing in 16 physically active young women at 30 and $120^{\circ}\cdot\text{s}^{-1}$ velocities. The experimental group (n = 10) received an interset rest period of 2.5, 5, and 10 minutes. They reported that isokinetics test protocols can utilize a rest period of 2.5 minutes without compromising the force production. These results is also different from the present study, this is may be due to the numbers of repetition performed in Bilcheck et al. (1993) study (30 reps). According to Brown and Weir (2001), strength and power isokinetics testing begin from a dead stop and consist of five or less maximal repetitions. Thus, contrasting these studies with the present investigation is difficult because of the different numbers of repetitive contractions performed in these studies.

In a more recent study, Parcell et al. (2002) using eleven health college-age men performed a study where the subjects underwent to a four maximal coupled contractions at 60, 120, 180, 240 and $300^{\circ}\cdot\text{s}^{-1}$. Velocity was administered in ascending order. Between sets rest periods of 15, 60, 180 and 300 s were assigned to volunteers in a counterbalance fashion. Parcell (2002) reported that a between rest period of at least 60 s is sufficient for recovery before the next test set. Different from the present investigation, Parcell et al. (2002) did not use a 30 s rest period. They considered that 30 s of rest is unlikely to be utilized by most investigators for experimental testing of maximal force production. However, the present study reported that a 30 s interset rest interval provided sufficient time for strength recovery in older subjects.

Four maximal isokinetics repetitions lasted an average of 6 s which may not lead to a complete fall in the phosphocreatine (PCr) stores of the muscle fiber. Fitts (1994) reported that with the onset of high intensity exercise, PCr shows a rapid decline reaching 5-10% of the pre-work value within 30 s. Also, it seems unlikely that PCr limits force production. The only possible mechanism implicating PCr would involve a reduced ATP resynthesis rate once PCr fell below some critical concentration (4). Likewise, Kushmerick and Meyer (1985) reported that PCr recovery following contractile activity occur in two phases. In human muscle, the initial phase shows a half time of 20-30 s.

CONCLUSIONS

The results of this study clearly demonstrate that peak torque production during a common isokinetic strength testing protocol is similar when older subjects are provided a between sets rest period of either 30, 60 or 90 s.

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KEY POINTS

- The assessment of muscular strength using isokinetics muscle contraction in older individuals is very important for exercise prescription and rehabilitation.
- The minimal time between intraset isokinetics knee extension assessment in older individuals need to be more investigated, however 30 s appear to be sufficient time for strength recover.

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