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Adaptations during familiarization to resistive exercise

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Abstract

This study focused on adaptations during familiarization to resistive exercise. It was also determined if familiarization requires one or more sessions. Twenty-six sedentary, college-aged females were matched and randomly assigned to one of two groups. Measurements were obtained during the initial familiarization period (Group 1: 15 trials on 1 day, Group 2: 5 trials on each of three consecutive days), and during retention tests scheduled two weeks and 3 months after the first test session. Elbow flexion torque and surface electromyography (SEMG) of the biceps and triceps were monitored concurrently. There were no significant differences between groups for any of the criterion measures. There was a significant ($p < 0.05$) increase (12.4 Nm, or 38.8%) in maximal isometric elbow flexion torque. Biceps (agonist) root-mean-square (RMS) SEMG exhibited a significant ($p < 0.05$) increase of 95 μV (29%). Triceps (antagonist) RMS SEMG underwent alternating decreases then increases, and each change was significant ($p < 0.05$). The ratio of biceps to triceps RMS SEMG was used to assess cocontraction, and it followed the same pattern of change as triceps RMS SEMG. We concluded that both groups responded in the same way to testing, regardless of the pattern of the first 15 contractions. The increase in maximal isometric elbow flexion torque was due to neural drive to the bicep (agonist). There was a low level of triceps (antagonist) cocontraction to provide joint stability, and it was adjusted throughout the duration of testing.

Keywords: Biceps brachii; Elbow flexion; Electromyographic activity; Resistive exercise; Antagonist cocontraction

1. Introduction

It is has been demonstrated that training-related changes in muscle strength are accompanied by a reduction in antagonist cocontraction (Carolan and Cafarelli, 1992). The explanation is quite reasonable: decreased antagonist cocontraction allows agonist muscle strength to manifest itself unimpeded by contraction of the opposing muscle group (Kamen, 1983). However, other studies on antagonist cocontraction following resistance training have reported mixed findings (Colson et al., 1999; Rutherford et al., 2001).

Two studies have examined the effects of eccentric training on the shape of the elbow flexion torque–velocity curve while monitoring agonist–antagonist SEMG concurrently (Colson et al., 1999; Rutherford et al., 2001). A significant increase in the overall magnitude and shape of the torque–velocity curve and in the amplitude of agonist SEMG activity at each velocity was observed by both research groups. The two studies also reported distinct, non-significant trends in antagonist cocontraction, but in opposite directions. Rutherford et al. (2001) observed a mean increase of 50% while Colson et al. (1999) reported an 11% decrease. Subject variability was implicated in both studies as the reason for non-significant findings.

Participants in the study by Colson et al. (1999) had two "task familiarization" sessions within 1-week prior to beginning 7 weeks of resistive exercise. Rutherford et al. (2001) did not report that subjects had any familiarization period; participants did however practice eccentric contractions twice a week for 4 weeks. Thus, one possibility is that alterations in antagonist cocontraction occur during the task familiarization period prior to the initiation of

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strength training studies. It has been theorized that antagonist cocontraction is a strategy that individuals employ when they are unfamiliar with the task requirements (Basmajian, 1977; Carolan and Cafarelli, 1992). The first several maximal effort contractions may be where the changes in cocontraction occur.

While interpreting the results of training studies it is important to consider the time-course of measurement (or observation) and the familiarization or practice effects that may be intentionally or unintentionally embedded within the experimental protocol. This is particularly important due to the existing literature that has shown altered cocontraction due to skill acquisition (Englehorn, 1983; Gabriel and Boucher, 2000; Hobart et al., 1975; Moore and Marteniuk, 1986) and to maintain joint stiffness (Baratta et al., 1988; Solomonow et al., 1988).

The purpose of this paper was, therefore, to study adaptations in cocontraction during familiarization to resistive exercise in novice participants. A secondary aim was to compare the effects multiple familiarization sessions to an equal number of practice trials within one session for stabilizing strength measures amidst what may be a rapid period of skill acquisition. The results of this study will clarify existing knowledge on rapid alterations in cocontraction during basic strength measurements and provide support for experimental design decisions that relate reliable measurement of muscular strength along a time scale that is appropriate for the given research questions.

2. Methods

2.1. Subjects

Twenty-six females (aged 18–32) participated in this study. Females were selected because they have smaller error variances than males during isometric testing (Kroll, 1970). The participants fit the following criteria: they had a body mass index (BMI) of less than 30; they were right-hand dominant; and they had not performed any upper-limb resistant training within the past year. The physical characteristics of the participants are presented in Table 1. An informed consent form was read and signed prior to participating in the study in accordance with Brock University's human ethics board. A written questionnaire to monitor activity levels was administered prior to the first session, and again on the last re-test to ensure no new activities were initiated during the study.

Table 1
Descriptive characteristics for the massed and distributed groups. Means and standard deviations for age, weight, height, forearm length and body mass index (BMI)

Physical characteristics	Group 1 ($M \pm SD$)	Group 2 ($M \pm SD$)
Age (yr)	24.08 ± 3.52	23.15 ± 3.74
Weight (kg)	59.47 ± 6.69	59.93 ± 8.01
Height (cm)	164.65 ± 5.31	165.76 ± 6.09
Forearm length (cm)	23 ± 1.2	23 ± 1.5
BMI (kg m^{-2})	21.88 ± 1.59	21.87 ± 3.26
Strength (Nm)	13.52 ± 3.7	14.65 ± 3.8
Sample size	13	13

2.2. Measurement schedule

The focus of this paper was on the familiarization period, prior to initiating a strength training regimen. Testing consisted of only 15 contractions to minimize metabolic and hypertrophic adaptations (Phillips, 2000). Re-tests were scheduled 2 weeks and 3 months after first session. If physiological adaptations occurred, such as a change in muscle fiber cross-sectional area, it would be dissipated over the rest intervals (Mujika and Padilla, 2001), leaving behind the effects due to familiarization. Since another five contractions were performed at each re-test, the total number of contractions was 25. Isometric contractions were used because the moment arm, length-tension of the muscle, and electrode location with respect to the muscle fibers remain constant during isometric contractions. Moreover, the force-velocity effects are eliminated as well (Dowling, 1997).

Because we are studying the first few contractions, subjects had to be matched and randomly assigned to their groups based on predicted elbow flexion strength. A regression equation that used weight and circumference of the upper arm was constructed based on data obtained from an earlier study (Gabriel et al., 2001a). Participants were ranked on predicted elbow flexion strength, and then assigned by matched pairs into one of two groups. Measurements were obtained during the initial familiarization period (Group 1: 15 trials on 1 day, Group 2: 5 trials on each of three consecutive days), and during retention tests scheduled 2 weeks and 3 months after the first test session (Fig. 1).

2.3. Recording torque and SEMG activity

All subjects listened to a pre-recorded tape to standardize each test session so that the maximal isometric elbow flexion contractions were 5-s in length with a 3-min rest period. This tape instructed them when to flex at the elbow as hard and as fast as possible when they heard "flex" in the recorded "ready and flex" statement. After 5 s the tape stated, "rest", and the subject were told to relax until told to "flex" again.

Participants were first seated in a testing chair (Fig. 2). Velcro straps were used to increase stability and minimize extraneous movements. The upper limb was supported at the back of the arm while shoulder and elbow were maintained at 90° of flexion in sagittal plane. The wrist was placed in a half-supinated position and secured within a cuff using Velcro straps, just below the styloid process. The wrist cuff unit was rigidly couple to the load cell (JR3 Inc., Woodland, CA) so the application of force was always perpendicular to the forearm.

Prior to electrode placement, the skin was lightly abraded and cleaned with rubbing alcohol to reduce signal