WORK ANALYSIS OF DUTY CYCLE EFFECTS FROM INJURIOUS STRETCH-SHORTENING CONTRACTIONS IN VIVO OF SKELETAL MUSCLE

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INTRODUCTION
Muscle damage and concomitant changes in performance due to stretch-shortening contractions (i.e., reciprocal eccentric/concentric contractions) is one of the major concerns in sports and occupational-related activities. Stretch-shortening exercise has been shown to produce muscle damage in humans. However, the dynamics of the movement were not controlled and muscle response was not quantified during the movement in these studies (e.g. Kyrolainen et al., 1998). Further, excitation-contraction fatigue has been shown to play an important role in skeletal muscle injury resulting from eccentric contractions (Warren et al., 2001). We hypothesized that (1) the stretch-shortening exercise would affect work output of muscle both during and 48 hours after exposure and (2) very short duty cycles (the time between contractions) would further disrupt excitation-contraction coupling, thus creating a larger work decrement than those associated with a longer duty cycle.

METHODS
All testing was performed with anesthetized male Sprague-Dawley rats (N=48) on a custom-designed rat dynamometer (Cutlip et al., 1997). The response of the dorsiflexor muscles to isometric and stretch-shortening contractions (SSC) were quantified in vivo. Rats were randomly assigned to three groups (N=8) having either 10-seconds, 1-minute, or 5-minute duty cycles. The testing consisted of 7 sets of 10 SSC performed at an angular velocity of 500°/s from 90° to 140° ankle angle for a total of 70 SSC (see Table 1). A single SSC was used as a test of work performance before, immediately after, and 48 hours after exposure to SSC sets. Negative work (eccentric contraction), positive work (concentric contraction), and net work (difference between negative and positive work) were examined. Work was calculated as the integration of force over ankle angle change. There was a 2 minute rest period between steps in the experimental protocol to minimize excitation-contraction fatigue.

Table 1. Experimental Protocol

<table>
<thead>
<tr>
<th>Step</th>
<th>Type</th>
<th>Duty Cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Single SSC</td>
<td>2min</td>
</tr>
<tr>
<td>2</td>
<td>7 SSC Sets of 10 Cycles</td>
<td>10s, 1min, 5 min</td>
</tr>
<tr>
<td>3</td>
<td>Single SSC</td>
<td>2min</td>
</tr>
<tr>
<td>4</td>
<td>Cage Recovery</td>
<td>48 Hour</td>
</tr>
<tr>
<td>5</td>
<td>Single SSC</td>
<td>2min</td>
</tr>
</tbody>
</table>

Negative, positive, and net work were calculated in the second SSC of each injurious SSC to examine performance decrements during the seven sets of SSC and to compare to work parameters from single SSC time points. The second SSC was used to minimize excitation-contraction coupling fatigue between sets.

RESULTS AND DISCUSSION
There was a pronounced decrement in single SSC negative and net work 48 hours after exposure for all groups, but these decrements were not specific to duty cycle (Figs. 1, 2). However, positive work was not affected 48 hours after exposure (Fig 3). During the 7 sets of SSC, net work showed a large decrement but was not specific to duty cycle (Fig. 4). In contrast, positive work and negative work of the 10 second group was most affected during the 7 sets of SSC (Figs. 5, 6). While duty cycle had an affect on real-time performance, it was not
reflected in the single SSC performance 48 hours after exposure.

![Figure 1: Single SSC Negative Work](image1.png)

![Figure 2: Single SSC Net Work](image2.png)

![Figure 3: Single SSC Positive Work](image3.png)

![Figure 4: SSC Sets Net Work](image4.png)

![Figure 5: SSC Sets Negative Work](image5.png)

![Figure 6: SSC Sets Positive Work](image6.png)

**SUMMARY**

Duty cycle appeared to have little effect on SSC 48 hours after exposure, but duty cycle did have an effect on real-time performance during the 7 sets of SSC. More contractions may give more pronounced results 48 hours after exposure. In addition, the similarity between single SSC and SSC sets indicated a good relationship between work parameters during and 48 hours after SSC.

**REFERENCES**

