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

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INTRODUCTION

Stretch-shortening contractions (SSC i.e., reciprocal eccentric/concentric contractions) resulting in muscle damage and concomitant changes in performance are one of the major concerns in sports and occupational-related activities. Stretch-shortening exercise has been shown to produce muscle damage in humans. However, dynamic measurements of force and length were not precisely controlled, or recorded in real-time (Kyrolainen et al., 1998). In addition, excitation-contraction coupling has been shown to play an important role in skeletal muscle injury resulting from eccentric contractions (Warren et al., 2001). We hypothesized that very short duty cycles during SSC, defined as the time between contractions, will result in a more pronounced isometric force decrement 48 hours after exposure as compared to longer duty cycles.

METHODS

All testing was performed with anesthetized male Sprague-Dawley rats (N=24) 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-second, 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). An isometric force test was used as a measure of static muscle performance at the optimal ankle angle of 90°. Isometric force tests were performed before, immediately after, and 48 hours after the 7 SSC sets. There was a 2 minute rest period between steps in the experimental protocol to minimize 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>F-L Curve</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>F-L Curve</td>
<td>2min</td>
</tr>
<tr>
<td>4</td>
<td>Cage Recovery</td>
<td>48 Hour</td>
</tr>
<tr>
<td>5</td>
<td>F-L Curve</td>
<td>2min</td>
</tr>
</tbody>
</table>

Dynamic force measurements were taken during the seven SSC sets to provide more quantitative information on real-time muscle performance. The force parameters used to evaluate the force changes between sets during the SSC were: 1) peak force (i.e, the maximum force achieved in the eccentric contraction), 2) minimum force (i.e. the force value prior to the eccentric contraction), and 3) cyclic force (i.e. the difference in the magnitude of force between the peak and minimum force). These force parameters were recorded for the second SSC in each set to evaluate the changes between sets. Force decrements were then compared between the static and dynamic tests.

RESULTS AND DISCUSSION

Compared to the 1-min group at 48 hours, the 10-sec and 5-min group showed a significant decrement in isometric force at an optimal ankle angle of 90° (Fig. 1). The dynamic force data showed a similar progression in performance between groups over the seven SSC sets (Figs 2, 3, 4). The peak and minimum force in the 10-sec group showed a more pronounced change than the other two groups. This was most likely the result of excitation-contraction coupling fatigue. However, this had no effect on the muscle’s
ability to produce eccentric force throughout the protocol as shown by the cyclic force (Fig 4).

**Figure 1:** Isometric Force Test

**Figure 2:** SSC Peak Force over 7 sets

**Figure 3:** SSC Minimum Force over 7 sets

**Figure 4:** SSC Cyclic Force over 7 sets

**SUMMARY**

Duty cycle appeared to have a small but significant decrement on muscle performance in isometric force at long and short duty cycles at 48 hours. This small decrement in force at 48 hours indicated that the muscle was at the threshold of injury. More contractions may yield more pronounced differences. The dissimilarity between dynamic force decrements and static force decrements among groups indicated that eccentric force performance during stretch-shortening cycles was not predictive of isometric force output 48 hours later.

**REFERENCES**

