Influence of load compliance on muscle fatigue in persons with multiple sclerosis

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SUMMARY
The present work compared the performance of individuals with multiple sclerosis on two types of fatiguing contractions that differed in the load compliance. Preliminary results indicated that decreases in load compliance lead to longer voluntary muscle contraction times in persons with multiple sclerosis.

INTRODUCTION
Fatigue is a common complaint of individuals diagnosed with multiple sclerosis (MS), and they are more fatigable than healthy control subjects (1,2). In healthy subjects, nonetheless, development of fatigue can be manipulated by changing the support of the limb during prolonged muscle contractions (3). Previous work has documented briefer times to failure (i.e. greater fatigability) for tasks involving the support of an inertial load (high-compliance task) compared with exerting an equivalent torque against a rigid restraint (low-compliance task)(4,5). One of the major reasons for this difference in performance has been traced to the adjustments that are made by the nervous system (4,5). As the two conditions impose different demands on the nervous system and MS is characterized by impairments in the function of central and peripheral nerve cells, it remains unclear how differences in load compliance impact the endurance capacity of MS patients. Manipulation of load compliance is known to influence performance on rehabilitation activities, such as open and closed kinetic chain exercises, but it is not known if the effect differs for individuals with MS.

The present study compared the performance of persons with multiple sclerosis on two types of fatiguing contractions that differ in load compliance.

METHODS
Seven (22-42 yrs; 5 women) mildly impaired individuals who were diagnosed with the relapsing-remitting form of multiple sclerosis participated in this study. The participants had a score of ≤4.5 on the Kurtzke Expanded Disability Status Scale (EDSS), which indicated that they were able to ambulate without the need for an assistive device. Three different experimental setups were designed to target elbow flexor, knee flexor, and ankle dorsiflexor muscles. Subjects participated in at least one set of experiments with two load compliances for one muscle group. The experiment on the elbow flexor muscles had the participants seated upright in an adjustable chair with the left forearm vertical and the upper arm horizontal. The forearm was supinated and the hand and forearm were placed in a modified wrist-hand orthosis tightly secured to the force transducer for the low-compliance task and attached to an inertial load for the high-compliance task. The experiments on the knee flexor muscles required the subjects to lie in a prone position with the left leg vertical and placed in a modified leg-foot orthosis that was either attached to the force transducer for the low-compliance task or from which an inertial load was suspended for the high-compliance task. The experiments on the dorsiflexor muscles required the subjects to be seated in an adjustable chair with the hip and knee at 90° of flexion. An adjustable brace was tightly secured around the foot and fixed to the force transducer for the low-compliance task or to the load for the high-compliance task. An adjustable bar was placed behind the leg during the high-compliance task to limit backward displacement of the leg.

In the three experimental setups, angle joint was measured with an electrogoniometer that was taped to the lateral side of the limb across the joint. The output of the force transducer and electrogoniometer was displayed on a monitor in front of the subjects during the two tasks. In addition to torque and angular position signals, the electromyogram (EMG) was recorded for elbow flexor (biceps brachii, brachioradialis) and extensor (triceps brachii) muscles during the elbow flexor tasks, the knee flexor (biceps femoris, semitendinous) and extensor (rectus femoris) muscles during the knee flexor tasks, and the dorsiflexor (tibialis anterior) and plantarflexor (soleus, gastrocnemius medialis) muscles during the dorsiflexor tasks.

Subjects participated in two experimental sessions in which the two fatiguing contractions, in a counterbalanced order, were performed for as long as possible. Both sessions began with the subject performing brief maximal voluntary contractions (MVC) to determine maximal value for torque and EMG. Subsequently, subjects exerted a constant torque (20% MVC) either against the force transducer (low-compliance task) or supported an equivalent mass (high-compliance task). The test joint was kept at 90° during both tasks. The low-compliance task was terminated when the subject was unable to maintain the required torque for 3s, whereas the high-compliance task was ended when joint angle deviated from the target angle by a predetermined...
amount for 3 s. Subjects were exhorted to sustain each fatiguing contraction for as long as possible.

RESULTS AND DISCUSSION
The time to failure was briefer for the high-compliance task compared with the low-compliance task for the three muscle groups, despite a similar decline in maximal torque at failure for the two tasks (Table 1). Similarly, the coefficient of variation for force increased to comparable values at task failure for both tasks, except for the knee flexion contractions (Table 1).

These changes were associated with an increase in EMG activity of the agonist and antagonist muscles. The coactivation ratio (antagonist EMG/agonist EMG x 100) decreased slightly during the elbow flexion and dorsiflexion tasks, as observed in healthy adults (3), but increased during the knee flexion tasks that were briefer than the tasks involving elbow or ankle joint (Figure 1).

As observed in healthy control subjects (3), these individuals with MS found the fatiguing contraction with the high-compliance load more difficult than when the limb was rigidly attached to a force transducer. There were differences among the three groups of muscles, however, as the knee flexors had a lesser ability to sustain the two tasks (Table 1) and the change in antagonist coactivation differed from the other two muscle groups (Figure 1). This observation is consistent with reports that the function of this muscle group is often compromised in individuals with MS (6). Another difference in these preliminary data was the reduced decline in MVC torque exhibited by the ankle dorsiflexors at task failure (Table 1).

CONCLUSIONS
These results indicate that the manipulation of load compliance can be used to examine the adaptations experienced by individuals with MS and to provide unique rehabilitation strategies.

ACKNOWLEDGEMENT
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REFERENCES

Table 1: Time to failure, decline in MVC torque, and change in the coefficient of variation (CV) for force for the low-and high-compliance tasks in the three investigated muscle groups

<table>
<thead>
<tr>
<th></th>
<th>Elbow flexion (n=4)</th>
<th>Ankle flexion (n=4)</th>
<th>Kneeflexion (n=3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Time to failure (s)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- mean (range)</td>
<td>1405</td>
<td>867</td>
<td>1491</td>
</tr>
<tr>
<td>ΔMVC torque (% before)</td>
<td>-29.2</td>
<td>-35.0</td>
<td>-18.4</td>
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<tr>
<td>ΔCV for force (% initial)</td>
<td>+254.5</td>
<td>+232.5</td>
<td>+384.7</td>
</tr>
</tbody>
</table>

Figure 1 – Changes in coactivation ratio (antagonist EMG/agonist EMG x 100) in the low-compliance (filled symbols) and high-compliance (open symbols) tasks performed with the elbow flexor (circles), ankle dorsiflexor (triangles) and knee flexor (squares) muscles.