LOWER BACK FNS FOR STABILIZATION DURING ONE-AND TWO-HANDED REACHING TASKS

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INTRODUCTION

An individual with a complete thoracic-level spinal cord injury (SCI) experiences a loss of voluntary control to the lower extremities, the pelvis, and a portion of the trunk. These limitations may make it difficult or impossible to perform seated tasks such as reaching, lifting, and pulling. A prototype functional neuromuscular stimulation device was developed to activate the trunk muscles for added stiffness during seated tasks. The particular studies described here involved evaluation of one-handed and two-handed reaching tasks using the Stimulation for Improved Trunk Stability (SITS) system prototype. The hypothesis was that using the SITS system would result in increased postural stability when compared to reaching tasks performed without stimulation.

METHODS

Subject #1 was a 34 year-old male with a T3 level complete injury, and Subject #2 was a 38 year-old male with a T6 level complete injury. The SITS system consisted of a control module that interfaced with an Octostim muscle stimulator. Adhesive surface electrodes were placed on the skin over the paraspinal muscle mass just lateral to the vertebral column. During one-handed reaching, three conditions were tested while seated in a wheelchair: unconstrained (U), constrained (C), and constrained with assistance from the stimulation system (SITS). Compensatory movements such as hooking an arm around the wheelchair frame were allowed in the U condition. Use of the non-dominant arm was deterred in the C condition by having the participant hold his arm to the side of his body. The two-handed reaching tasks were tested using the U and SITS conditions. Reflective markers were tracked by a Motion Analysis video system, and the wheelchair wheels were positioned on four load cells. Video data were used to determine object trajectory, targeting accuracy, and trunk displacement.

One-handed reaching tasks involved moving a 1 kg mug between nine targets on a table. Targets were located at 60% (6), 90% (9), and 120% (12) of seated reach (measured with trunk vertical) at the midline (M) and half the shoulder width to the left (L) and right (R). For example, L6R6 indicates moving from the left 60% to the right 60% target. A successful movement was defined as the final object position being within 80% reaching distance from the target. Five repetitions of six reaching combinations for three conditions (U, C, SITS) were performed over two days (180 trials). For the two-handed reaching tasks, the table was removed, and the mug was manipulated through a series of movements. The three tasks were moving and holding the object: 1) above the head, 2) at eye-level with arms extended, and 3) with the arms extended on the dominant side of the body. Five repetitions of the three two-handed tasks for two conditions (U, SITS) were performed over two days (60 trials).

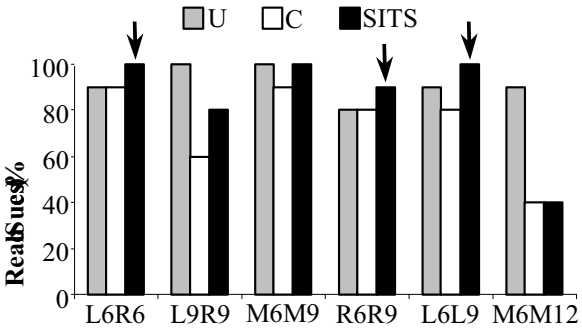

Figure 1: One-handed reaching success. Arrows indicate movements where the SITS system appeared beneficial.

RESULTS AND DISCUSSION

Combining data for one-handed reaching tasks, the percentage of successful movements was highest for the U condition (92%), followed by the SITS (89%) and C (84%) conditions. Similarly, trunk displacement was minimized in the U condition (1.8 cm), followed by the SITS (2.6 cm) and C (3.1 cm) conditions. Figure 1 shows representative data from Subject #1 for the percentage of successful movements as a function of reaching combination. When combining data for the two-handed reaching tasks, trunk displacement did not show differences between the U and SITS conditions. Wheelchair center of pressure displacements were reduced for the SITS condition (7.4 cm) as compared to the U condition (10.8 cm). Maximum wheelchair center of pressure velocities were also reduced for the SITS condition (68.1 cm/s) as compared to the U condition (84.5 cm/s) indicating that the task was more controlled with the stimulation than without.

Compensatory movements such as arm hooking (U condition) may be ergonomically unfavorable. One goal of designing the SITS system was to provide enough trunk stability that compensatory movements would be unnecessary. The SITS system appeared to be helpful for the one-handed combinations that involved reaching to the right or left (Figure 1). In addition, the SITS system may have been most beneficial for two-handed reaching tasks, particularly those that involved lifting an object over the head. Center of pressure data supported observations that the SITS system provided additional postural stability to maintain targeted two-handed reaching postures. Overall, the participants continued to reach most effectively with the U condition, while the SITS system provided additional lower back stiffness that resulted in consistent improvement over the C condition.

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