EVALUATION OF UPPER EXTREMITY MUSCLE ACTIVITY DURING MANIPULATION IN ROBOT-SIMULATED TASK ENVIRONMENTS

[1,2] H.A.M. Seelen, [1] R.P.J. Geers, [1] Y.J.M. Janssen-Potten
[1] Institute for Rehabilitation Research, Hoensbroek, The Netherlands
[2] Rehabilitation Foundation Limburg, Hoensbroek, The Netherlands
ham.seelen@irv.nl

INTRODUCTION

Arm-hand function (AHF) is essential in activities of daily living. In patients suffering from cervical spinal cord injury (C-SCI) AHF is severely impaired. During rehabilitation they have to learn to use their residual capacities to (partially) compensate for the loss of function [1]. In some cases muscle transpositions are carried out to restore a specific arm or hand function. Many AHF test use a time score as a critical factor. However, such tests do not provide insight in either the quality of movements, nor in the mechanisms that govern compensation of function loss and the associated changes in muscle co-ordination that occur in C-SCI patients [2].

A 3D robotic arm (HapticMaster, FCS Control Systems BV, NL) has been developed with which movement-specific force may be exerted on a subject performing an upper extremity task, thus controlling the movement trajectory/position, velocity and acceleration of the arm (figure 1).

The aim of the present study is to investigate the potency of the HapticMaster (HM) in simulating activities of daily living (ADL) and to investigate the effects of specific changes in the applied force and resistance on muscle activation patterns during upper extremity task performance.


Figure 1: Experimental setup **Figure 2:** Cylinder grip

METHODS

15 healthy volunteers, (m/f=6/9; mean age 24.6 yr, range 21-30 yr; mean height 1.76 m, range 1.50-2.00 m) participated. Subjects, while seated, performed 2 standardised ADL tasks, i.e. lifting a full soft drink can vertically over a distance of 30 cm (phase 1) and back (phase 2) using a cylinder grip (task A) (figure 2) and moving a small light weight object horizontally over a distance of 30 cm from left to right and back using a 3-point grip (task B). Task C and D were identical to A and B as to spatial displacement, but objects' masses were simulated by the HM. Each task was performed 8 times (trials).

Activity of 21 (focal and postural) muscles of the arm and trunk was recorded using surface EMG (sample rate: 1000 Hz; Sample time: 7s. Also object displacement was recorded using an IR-camera system (PRIMAS, Delft Motion Analysis, Delft, NL). Data were analysed off-line using MATLAB (The Math Works Inc., Natick, Mass). EMG data were full wave rectified, low-pass filtered (2nd order Butterworth filter) and normalised to the movement cycle (figure 3). Within-subject signal reproducibility and between-subject signal similarity were assessed using intraclass correlation coefficients (ICC) across trials. Similarity between muscle activation patterns between task A/C and B/D was assessed by calculating correlation coefficients (R) for all muscles.

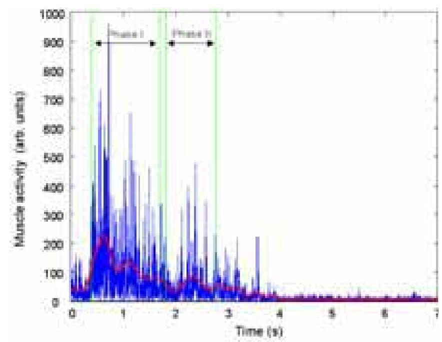

Figure 3: Example of EMG recording

RESULTS AND DISCUSSION

Within-subject reproducibility, expressed as mean ICC, was higher than 0.80 in 77.4% of all cases. ICC values in task A and C were generally higher than in task B and D. ICC values associated with between-subject reproducibility were higher than 0.60 in 79.8% of all cases. Mean R-values were above 0.60 in 81.0% of cases for task A and C and in 95.2% of cases for task B and D.

CONCLUSIONS

During the 'real world' ADL tasks and the HM simulated tasks similar muscle coalitions were activated. This finding corroborates the idea that the HM may be used to develop and adequately simulate upper extremity tasks conditions with which arm muscle function may be evaluated. This is especially important in those persons whose arm function is impaired and who receive rehabilitation treatment to improve their arm-hand function performance. Next to the evaluation aspects the HM may offer the opportunity to train arm performance in patients with sensorimotor deficits caused by impairments of the central nervous system.

REFERENCES

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