Application of Novel Biointerface In Stroke Rehabilitation.

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Introduction

Many neurological disorders involve partial or complete paralysis, and involve the patient in extensive and costly rehabilitation involving outpatient visits with an occupational therapist, who traditionally tracks a patient's progress with a series of subjective tests.

By packaging a comfortable biofeedback interface consisting of an array of pressure sensors with an intuitive GUI, it may be possible to deliver a rehabilitative device that not only provides real-time high-fidelity registration of a patient's neuromuscular activity, but also quantifies the patient's progress over time, permitting self-administration of a rehabilitation protocol in an simple and non-invasive interface.

The present study, conducted at JFK Rehabilitation Institute (Edison, NJ) investigates the application of this novel interface to the rehabilitation of hemi-paretic stroke patients.

Experimental Design

24 stroke patients, complete a set of upper limb exercises designed to increase range of motion and motor control in the upper limb twice weekly for 8 weeks. Subjects are not discriminated by gender, age, or by which side is affected by the stroke, but are expected to be 6 months 4 years post stroke.

Figure: MKI sleeve and MAST devices: Sleeve array of Force-Sensitive resistors wearable on forearm; Arm support device for extension about the elbow.

Sitting upright in a chair outfitted with the Mechanical Arm Support Tracker (MAST), the subject dons the MyoKinetic Interface on their affected forearm and rests their arm in the MAST. All exercises are conducted in this setup, entire protocol lasts for less than 1 hour.

Protocol

Subjects complete a series of grasping and extending motions and a series of elbow flexion and extension exercises. Each grasping and extending exercise is performed 3 5 times per session, 30 seconds per repetition. 3 sets of 5 elbow range of motion exercises are completed.

Exercise	Classification	Device	SetsxReps
Whole Hand Extension	Hand	MKI	1x5
Discrete Hand Extension	Hand	MKI	1x2cycles
Thumb Extension	Hand	MKI	1x3
Index Finger Extension	Hand	MKI	1x3
Whole Hand Grasp	Hand	MKI	1x5
Discrete Hand Grasp	Hand	MKI	1x2cycles
Elbow Range of Motion	Elbow	MAST	3x5

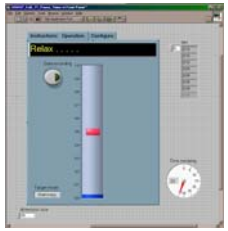


Figure: Subjects attempt to maintain exertion at a target level: LabView screen shot, and subject donnig sleeve. Sleeve is calibrated and normalized to the individuals resting minimum and maximum voluntary capabilities for each exercise.

Preliminary Results

Results for the first 4 subjects yield promising results. For each exercise, sets were analyzed, and averaged over all reps, yielding the vector (v_i) of perfomance descriptors M_i (i ranging over days 1:16):

$$v_i = \frac{1}{k \cdot j} \sum_{k=1}^{1\to3} \sum_{j=1}^{3\to5} M_{ji}^{k}$$

where j and k iterate over repetition and set, respectively. The principal descriptors of interest were 1) variance about the target, 2) overshoot at the onset of step response, and 3) length of repetition spent in the "hot zone" (the range covered by the red target on screen: [0.45 055]).

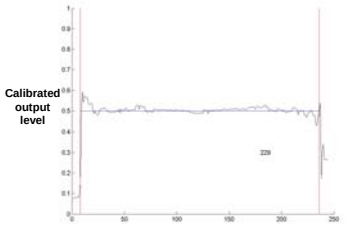


Figure: Sample wave-form from subject attempting to match a target at 0.5

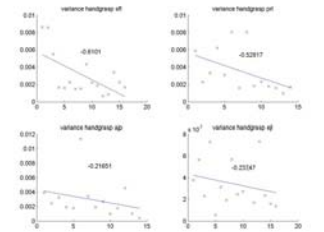
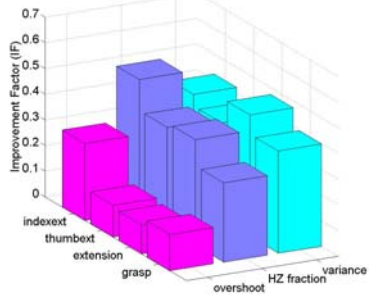


Figure: Sample results depicting variance of handgrasp exercise for 4 subjects over 16 days with linear fit.

$$IF \equiv \frac{f_f - f_i}{v_{max} - v_{min}}$$

Improvement factor (IF) calculated as the ratio of final initial fit curve pts to the max and min data points in the vector of data descriptors.



Exercise	Overshoot	HZ Fraction	Variance
Whole Hand Extension	0.47	0.41	0.47
Thumb Extension	0.12	0.39	0.38
Index Finger Extension	0.30	0.51	0.42
Whole Hand Grasp	0.14	0.31	0.40

Discussion

Because the study has not yet been completed, conclusions can not yet be drawn, though the data generated from the MKI has demonstrated marked improvement in subject performance. A control must be run to compare to healthy subject improvement over time, and a parallel study is currently under way to determine the relationship between muscle displacement in the forearm as a rigid body and force production at the hand.

Thanks JFK Rehab: Elsa Zavoda OT, Steven Escaldi DO.