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# A Guided Exercise Tool with Quantitative Measures of Rehabilitation Progress: Upper-Limb Motor Control Following Stroke

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## Abstract

Retraining of simple motor tasks such as flexion and extension about the elbow is critical to restoration of function to the upper-limb following stroke. We have developed a device for such an intervention. The Hand-Arm Rehabilitation Interface (HARI) supports the arm against gravity via a sturdy and mobile Mechanical Arm Support and Tracker (MAST) which simultaneously allows for ease of motion and digitization of the patient activity for real-time biofeedback display and record-keeping for analysis by the clinician. Herein we present the results of a pilot investigation of HARI in stroke rehabilitation, as well as the Rehab Array, a novel method of data compilation and analysis.



**10 Subjects**  
57 ± 18 years old  
7/3 Male/Female  
15 ± 17 months post-stroke  
6/4 R-Side/L-Side affected  
3.8 ± 1.3 Chedoke-McMaster score

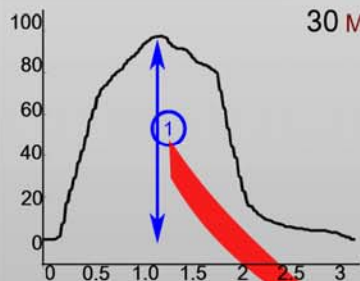
## Protocol

8 weeks x 2 sessions/week  
3x(5-10) elbow flexions & extensions  
Adequate warm-up/stretching  
Arm support provided by HARI  
Real-time biofeedback display

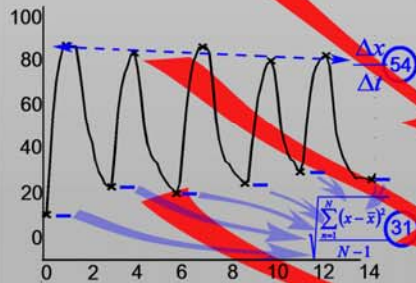
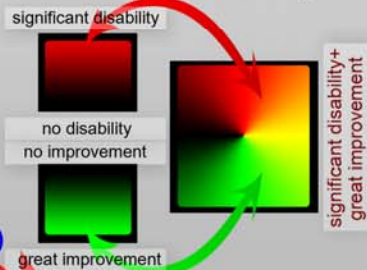


## Feature Extraction

78 Features of patient performance extracted from each repetition



30 Measures of Absolute Performance  
24 Measures of Consistency  
24 Measures of Fatigue



- 1. Normal Flexion about the elbow
- 54. Moderate fatigue elbow flexion
- 31. Highly variable extension ROM

## Results

Using HARI to retrain their reaching motions subjects exhibited an increase in range, consistency and stamina in flexion tasks.

### Maximum Flexion

Performance	increased 2.8° ± 3.9°
Consistency	increased 36% ± 53%
Fatigue	decreased 110% ± 25%

Jerkiness, calculated by the number of changes in the direction of the velocity vector, decreased and was consistently reduced.

### Jerkiness

Performance	decreased -13.8 ± 27.2 (34% ± 27%)
Consistency	increased 36% ± 50%

## Acknowledgement

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## Disability



## Recovery



1. Subject 1  
2. Subject 2  
3. Subject 3  
4. Subject 4  
5. Subject 5  
6. Subject 6  
7. Subject 7  
8. Subject 8  
9. Subject 9  
10. Subject 10



## Rehab Array

## Performance

- Maximum ROM
- Minimum entry
- Minimum exit
- Global minimum
- Total Range
- Count (Fl=GlB)
- Count (Ext=GlB)
- Mn(Ex)-Mn(Ent)
- Count(Fl>Ext)
- Range(Flx)
- Range(Ext)
- Stall: Peak
- Stall: Flex
- Stall: Ext
- Peak Pctge
- Ramp: Flex
- Ramp: Ext
- Count(Val Sw)
- Max Flex Locn
- Max Ext Locn
- Half Flex Locn
- Half Ext Locn
- Half Max Dist
- gHalf Flex Fract
- gHalf Ext Fract
- gHalf Max Dist
- Diff HMax Flex
- Diff HMax Ext

## Consistency

- std(1)
- std(2)
- std(3)
- std(4)
- std(5)
- std(8)
- std(10)
- std(11)
- std(12)
- std(13)
- std(14)
- std(15)
- std(16)
- std(17)
- std(18)
- std(19)
- std(20)
- std(21)
- std(22)
- std(23)
- std(24)
- std(25)
- std(26)
- std(27)
- std(28)

## Fatigue

- slope(1)
- slope(2)
- slope(3)
- slope(4)
- slope(5)
- slope(8)
- slope(10)
- slope(11)
- slope(12)
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