UPPER EXTREMITY ROBOTIC THERAPY IN STROKE PATIENTS WITH SEVERE UPPER EXTREMITY MOTOR IMPAIRMENT

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INTRODUCTION

Chronic motor deficits in the upper limb are a major contributor to disability following stroke. Although it has been shown that improvements in motor function are most likely in the initial three months following stroke, recent research has demonstrated that gains in motor function can occur with intensive motor learning-based rehabilitation in people even many years post-stroke (1,2). The purpose of this study was to investigate the effect of robotic therapy on motor function and robot derived performance measures in patients with chronic, severe upper extremity (UE) impairments after stroke.

METHODS

As part of a larger study, 15 individuals with chronic, severe UE paresis (Fugl-Meyer <15) after stroke (> six months post onset) performed 18 sessions of robot-assisted UE rehabilitation consisting of goal-directed, planar reaching tasks over a period of three weeks. The robot testing involved the subject reaching for each target, clockwise around the circle pattern without movement assistance from the robot. A movement began when the speed first became greater than 2% of the peak speed and ended after the speed dropped and remained below the 2% threshold again. Kinematic variables derived from the robot evaluation data were aiming error (mean absolute angle between actual direction and a straight line between start and target), mean speed (total distance traveled over total movement duration), peak speed, mean-to-peak speed ratio (mean speed divided by the peak speed which has previously been used as a metric of movement smoothness) (3) and movement duration. Outcome measures included the Fugl-Meyer Assessment, the Motor Power Assessment, the Wolf Motor Function Test, and five robot derived measures (aiming error, mean speed, peak speed, mean: peak speed ratio and movement duration). Student t-tests evaluated differences between baseline and post-treatment outcomes ($p \leq 0.05$). Cohen's *d* was calculated to determine the effect size of treatment on the clinical and robot-derived measures.

RESULTS AND DISCUSSION

Training produced statistically significant improvements from baseline to discharge in the Fugl-Meyer and Motor Power Assessment scores, and in the quality of motion (quantified by a reduction in aiming error and movement duration with an increase in mean speed and speed ratio variables-Table 1). These findings provide evidence that persons with severe UE paresis long after stroke onset can demonstrate reduced motor impairment with a brief, intense robot-assisted intervention. Previous research showed that early in recovery post-stroke, a patient's movements are composed of short, sporadic sub-movements with a series of peaks and valleys. As subjects improved with training, reaching movements became smoother with fewer stops, suggesting improved inter-joint coordination and neural recovery processes (3). In the present study, large treatment effects for the robot-derived measures indicate that movement accuracy and smoothness did improve with practice in these individuals with severe, chronic paresis.

CONCLUSIONS

Our findings indicate that robot-assisted UE rehabilitation can reduce UE impairment and improve the quality of motion in patients with severe UE impairments from chronic stroke.

REFERENCES

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Table 1: Means (standard error of mean) for robotic outcome variable scores at baseline, post treatment

N=15	Aiming error (radians)	Mean Speed (m/sec)	Peak Speed (m/sec)	Mean-to-Peak Speed Ratio	Movement Duration (sec)
Baseline	1.144 (0.040)	0.038 (0.004)	0.138 (0.012)	0.284 (0.013)	4.850 (0.366)
Post-Treatment	1.009 (0.055)	0.046 (0.004)	0.131 (0.011)	0.360 (0.016)	3.357 (0.334)
Change	-0.136 (0.038)	0.007 (0.002)	-0.006 (0.005)	0.076 (0.012)	-1.492 (0.310)
Effect size (Cohen's *d*)	0.73	0.37	0.14	1.38	1.10
p-values	<0.01*	<0.01*	0.27	<0.01*	<0.01*

* = Significant change baseline to discharge