SURVIVORS OF STROKE MAY ACHIEVE CYCLIC REACHING: A BIOMECHANICAL ANALYSIS OF THE HEMIPARETIC AND LESS-AFFECTED UPPER-EXTREMITIES.

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INTRODUCTION

Motor control impairments following a stroke impact the ability to generate coordinated reach. Research has demonstrated improvements in the amount of hemiparetic arm use, yet less attention has been devoted to quantifying the quality of use [1]. One potential contribution to the quality of movement is the underlying structure of a reaching task. For example, reaching can be cyclic, i.e. continuous back and forth, or discrete, i.e., defined start and stop. Research on neurologically intact individuals has demonstrated advantages of cyclic reaching including faster movement velocity and smoother trajectories [2]. A key component of cyclic reaching is the ability to produce continuous motion (i.e. not stopping/dwelling on targets). Survivors of stroke, however, often demonstrate segmented movements during forward discrete reaching (i.e. not smooth), and no study has directly addressed the ability to generate cyclic reaching comparing the stroke-affected to the less-affected side. This purpose of this study was to describe cyclic reaching in survivors of stroke in order to evaluate its potential to be incorporated in stroke-rehabilitation interventions aimed at improving the quality of movement.

METHODS

Eight survivors of stroke (5 male; mean age 68.5 years, range 44-86) in the chronic stage of recovery (mean 40 months post-stroke; range 7-82) participated. Subjects met gross and fine-motor criteria for intensive interventions (e.g., ability to extend wrist). Subjects sat comfortably in a chair and were asked to reach between two targets 0.35 m apart (anterior-posterior direction) at a height of 0.71 m (approximate height of a computer desk). The initial starting position was with the shoulder at neutral and the elbow at 90 degrees of flexion. Subjects were instructed to reach as quickly and as accurately as possible. The pressure sensitive targets were used to quantify beginning/end of reaching cycles. One trial of cyclic reaching (5 cycles) was performed with both the affected and less-affected upper-extremity; order of trials was randomized. A 7-camera Vicon system recorded the motion of the subject’s torso and upper extremities. Kinematic data were processed in Visual 3D for outcome measures of interest including:

- time to reach between each target (forward and return, sec),
- peak reach and return velocity (m/sec)
- anterior trunk displacement (m), shoulder range of motion (ROM, degrees), elbow ROM (degrees) during forward reach.
- Movement units during forward reach (number of zero velocity crossings of marker on wrist).

Data were averaged over the 5 reaching cycles and were analyzed with RMANOVA (significance p<0.05).

RESULTS AND DISCUSSION

Subjects reached towards the anterior target significantly faster with the less-affected upper-extremity compared to the stroke-affected side (0.78 sec vs. 1.5 sec, p<0.01), resulting in greater peak velocities (1.0 m/sec vs. 0.64 m/sec, p<0.05). The ability to generate cyclic reaching is considered to be dependent on continuous motion which is evident on velocity profiles. As depicted in Figure 1, the velocity profiles are smooth and continuous when reaching with the less-affected side (i.e., no dwelling on targets); however, corrective submovements are more commonly present when reaching with the stroke-affected side. Figure 1 represents data from two subjects: the subject in panel A is able to generate smooth, continuous motion without dwelling (periods of zero velocity), whereas the subject represented in panel B has
prolonged durations at target contact represented by periods of zero velocity.

![Image](image1.jpg)

**Figure 1:** Cycling reaching velocity profiles of 2 representative subjects. This figure also depicts longer reaching durations and smaller peak velocities when reaching with the stroke-affected arm. Scales are consistent across panels.

Movement units represent quantification of reaching smoothness (i.e., the number of zero velocity crossings while reaching forward). The absolute number of movement units was significantly less when reaching with the less-affected arm and hand ($p<0.01$). On average, 16% of the cyclic reaches had secondary movements when reaching with the less-affected arm (i.e., movement correction at target contact) whereas 24% of the reaches had secondary movement with the stroke-affected arm. These observations are consistent with previously reported data [2], suggesting that survivors of stroke may achieve cyclic reaching within a range similar to a neurologically intact population.

As demonstrated in Figure 1, however, the potential exists that not all survivors of stroke can accomplish cyclic reaching (bottom right panel). One reason may be the difficulty extending the elbow during forward reach. As depicted in Figure 2, survivors of stroke utilized an anterior trunk displacement strategy which was observed with decreased shoulder flexion and elbow extension when reaching with the stroke-affected arm compared to the less-affected arm.

![Image](image2.jpg)

**Figure 2.** Anterior trunk displacement, shoulder ROM, and elbow ROM during forward reach with the less-affected and stroke-affected arm. (Error bars represent SEM; * indicates $p<0.01$)

Figure 3 further illustrates the relationship of elbow extension and movement smoothness. Those subjects that demonstrated greater elbow extension had fewer movement units which fell under the spread of movement units when reaching with the less-affected side.

![Image](image3.jpg)

**Figure 3.** Elbow extension is correlated with the number of movement units when reaching with the stroke-affected, but not the less-affected arm.

**CONCLUSIONS**

Survivors of stroke may achieve cyclic reaching. The ability, however, may depend on the degree of elbow extension. These findings have implications for incorporating cyclic reaching during interventions.

**REFERENCES**


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