INTRODUCTION

Over 780,000 persons in the United States have a new or recurrent stroke each year.[1] Despite therapeutic efforts, as many as 80% of persons with stroke continue to have residual deficits, particularly within the paretic, affected limbs. Studies have suggested the possibility that in individuals with stroke the upper extremity ipsilateral to the lesion may exhibit deficits, although it has been traditionally considered to be “unaffected”.[2] While reaching movement kinematics have been shown to be different between the affected and unaffected limbs in persons with chronic stroke, greater impairment in the paretic limb was related to altered movement patterns in the unaffected limb.[3] Additionally, greater deficits in movement patterns of the unaffected limb have been reported in individuals with left hemispheric damage.[4] The purpose of this preliminary study was to a) compare reaching kinematics of the “less affected” limb, stratified by side of hemispheric lesion, in persons with chronic stroke and to b) compare reaching kinematics stratified by side of hemispheric lesion to a group of matched, individuals without stroke.

METHODS

Fifteen individuals with upper extremity impairment from chronic stroke (right hemispheric lesion = 8, left hemispheric lesion = 7) and seven individuals without stroke participated. (Table 1) All participants were right hand dominant. Following informed consent, the upper extremity section of the Fugl-Meyer Motor Assessment (FM-UE) was performed to clinically document level of impairment in the paretic limb in the participants with stroke. While seated with the trunk restrained, participants performed three repetitions of unilateral reaching to targets, level with the top of a table, located ipsilateral and contralateral to the limb. Participants were instructed to reach to the target at a self-selected, comfortable speed as well as a condition of reaching to the targets as fast as possible. Order of target location, reaching limb and speed condition were randomly presented.

Three-dimensional kinematic data of upper extremities and trunk were collected (MotionMonitor™ Minibirds, 100Hz) during the reaching tasks. International Society of Biomechanics International Shoulder Group recommendations for definition of global and local coordinate systems as well as Euler rotation sequences for segmental and joint motions were followed.[5] Data were exported and processed with custom routines in Excel™ with movement initiation defined as the time when tangential velocity exceeded 5% of maximal velocity and end of movement defined when the velocity dropped below this 5% threshold. Scapulohumeral, trunk and elbow kinematics as well as mean speed, peak speed, smoothness metric (mean speed/peak speed)[4] and movement duration were calculated.

Pearson correlations (r, p≤0.05) determined if relationships existed between the FM-UE and the movement kinematics of the “less affected” limb during ipsilateral and contralateral reaching. Independent t- tests (p≤0.05) compared right vs. left sided hemispheric lesion groups as well the control group left extremity with left hemispheric lesion group and control group right extremity with right hemispheric lesions for ipsilateral and contralateral reaching during each speed condition. Given the small sample, Cohen's d was calculated to determine the strength of the comparative relationships with effect size defined as small (d≥0.2), medium (d≥0.5) or large (d ≥ 0.8).

RESULTS AND DISCUSSION

A moderate inverse relationship (r = -0.479, p =0.071) was found between the FM-UE and movement smoothness across the fifteen
participants with impairment from stroke. When compared to controls, the left lesion group had significantly greater (p=0.001) shoulder flexion for the contralateral fast speed condition. Overall, shoulder flexion was increased, with large effect sizes, in all four reaching conditions in the left hemispheric lesion group. Medium to large effect sizes were found in both reaching directions at self selected speed with the left hemispheric lesion group demonstrating reduced smoothness, increased shoulder flexion and reduced elbow extension compared with the control group.

Decreased peak velocity (p=0.041) of the right lesion group was found in the ipsilateral self selected reaching condition compared with the controls. Additionally, with large effect sizes, this condition revealed the right lesion group to have reduced mean speed, smoothness, movement duration with increased shoulder flexion. The greater shoulder flexion angle with large effect size was demonstrated in the right lesion in all four reaching conditions.

When comparing right vs. left lesion groups, significantly greater smoothness (p=0.039) was found in the right hemispheric lesion group compared with left in fast speed ipsilateral reaching condition. Although not statistically different, the right hemispheric lesion group consistently had lower peak speed with greater movement smoothness with medium to large effect sizes demonstrated across both ipsilateral speed conditions and the contralateral self-selected speed condition. Figure 1.

CONCLUSIONS
The preliminary findings of this study reveal that differences do exist in reaching kinematics of the “less affected” limb in individuals with chronic stroke as compared with individuals without stroke. Overall, the group with stroke demonstrated reduced movement smoothness with a movement strategy of increased shoulder flexion when reaching to designated targets, regardless of movement speed or hemispheric lesion. In agreement with previous literature[4] the “less affected” extremity of persons with a right side hemisphere stroke demonstrated improved movement smoothness compared with left hemispheric lesions.

REFERENCES

Table 1: Demographic characteristics by group (means ± sd)

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Left-sided lesion</th>
<th>Right-sided lesion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n=7)</td>
<td>(n=7)</td>
<td>(n=8)</td>
</tr>
<tr>
<td>Age (yrs)</td>
<td>55.9 ± 10.8</td>
<td>66.6 ± 5.5*</td>
<td>57.9 ± 8.5</td>
</tr>
<tr>
<td>Gender (male/female)</td>
<td>2/5</td>
<td>5/2</td>
<td>4/4</td>
</tr>
<tr>
<td>Stroke_onset (months)</td>
<td>n/a</td>
<td>59.3±52.0</td>
<td>87.1±47.9</td>
</tr>
<tr>
<td>Fugl-Meyer_UE (max = 66)</td>
<td>n/a</td>
<td>50.4 ± 17.7</td>
<td>46.7 ± 20.1</td>
</tr>
</tbody>
</table>

*Indicates significant difference from other groups (p≤0.05)

Figure 1: Movement smoothness by groups