BRIEF REPORT

Behavioral, Neurophysiological, and Descriptive Changes After Occupation-Based Intervention

Camille Skubik-Peplaski, Cheryl Carrico, Laurel Nichols, Kenneth Chelette, Lumy Sawaki

OBJECTIVE. We evaluated the effects of occupation-based intervention on poststroke upper-extremity (UE) motor recovery, neuroplastic change, and occupational performance in 1 research participant.

METHOD. A 55-yr-old man with chronic stroke and moderately impaired UE motor function participated in 15 sessions of occupation-based intervention in a hospital setting designed to simulate a home environment. We tested behavioral motor function (Fugl-Meyer Assessment, Stroke Impact Scale, Canadian Occupational Performance Measure) and neuroplasticity (transcranial magnetic stimulation [TMS]) at baseline and at completion of intervention. We collected descriptive data on occupational participation throughout the study.

RESULTS. All behavioral outcomes indicated clinically relevant improvement. TMS revealed bihemispheric corticomotor reorganization. Descriptive data revealed enhanced occupational performance.

CONCLUSION. Occupation-based intervention delivered in a hospital-based, homelike environment can lead to poststroke neuroplastic change, increased functional use of the affected UE, and improved occupational performance.


Stroke occurs once every 40 s in the United States, resulting in 795,000 new strokes per year and making stroke the leading cause of long-term disability (Lloyd-Jones et al., 2009). Two-thirds of stroke survivors experience upper-extremity (UE) impairment (Rosamond et al., 2008), which can lead to difficulty performing meaningful occupations (Trombly & Ma, 2002). UE motor function after stroke improves in response to activity-based movement therapy (Richards, Stewart, Woodbury, Senesac, & Cauraugh, 2008). This improvement has been linked to neuroplastic change (Cramer & Bastings, 2000; Johansson, 2011; Liepert et al., 1998; Nudo, 2003).

Occupation-based intervention is a form of activity-based therapy consisting of client-directed occupations that match client-identified goals (American Occupational Therapy Association [AOTA], 2008). Principles of occupation-based intervention (Trombly & Ma, 2002) appear highly concordant with principles of interventions to drive neuroplastic change (Klein & Jones, 2008; Nudo, 2003). Therefore, occupation-based intervention could conceivably result in measurable neuroplastic change. However, no studies have directly measured neuroplastic change in relation to occupation-based intervention.

Thus, the purpose of this case study was to use transcranial magnetic stimulation (TMS) to investigate the nature and extent of neuroplastic change associated with occupation-based intervention and recovery of UE motor function in 1 research participant with chronic stroke. Researchers have made extensive use of TMS in measuring neuroplastic change associated with interventions to promote UE motor recovery (Bastings, Greenberg, & Good, 2002; Liepert et al., 1998; Rossini et al., 1998). By conducting the first investigation of neuroplastic change associated with occupation-based intervention, we can establish further evidence of how occupation-based intervention affects...
mechanisms underlying functional recovery after stroke.

Method

Research Design

This single-subject case report reflects a pretest–posttest design. We obtained informed consent per our institution’s Institutional Review Board mandates. Inclusion criteria included having had one stroke >1 yr before enrollment (i.e., chronic status). We structured exclusion criteria primarily to minimize risks associated with TMS and to control for potential confounding variables. Exclusion criteria included (1) history of head injury with loss of consciousness; (2) seizures; (3) severe alcohol or drug abuse; (4) severe psychiatric illness interfering with participation in the study; (5) cognitive deficits severe enough to preclude informed consent; (6) ferromagnetic material near the brain; or (7) cardiac or neural pacemakers. To approximate the treatment frequency and duration typically mandated by outpatient rehabilitation reimbursement entities, we conducted 55-min intervention sessions, 3 times per week for 5 wk. An occupational therapist with graduate education in rehabilitation sciences and 26 yr of clinical experience with neurological populations provided the intervention. The therapist had no involvement with administration of assessments.

Participant

The participant, “Will,” experienced a right middle cerebral artery infarct resulting in left hemiparesis. Will volunteered for our study in response to a referral from his attending rehabilitation physician. On enrollment in the study, Will was 55 yr old. His first and only stroke occurred 15 mo before enrollment. After his stroke, he received standard inpatient and outpatient occupational therapy. He completed his last round of outpatient therapy 4 mo before enrollment. He had right-hand dominance before and after his stroke. With cueing, Will used his affected UE as a gross active assist. Visual inspection revealed limited range of motion in all joints, limited isolated finger movements, and flexor synergy. He also had a Modified Ashworth Scale (Platz, Eickhof, Nuyens, & Vuadens, 2005) score of 2. On the basis of his Fugl-Meyer Assessment (FMA; Gladstone, Danells, & Black, 2002) score (Table 1), we classified his hemiparesis as moderate.

Instruments

Behavioral assessments. We completed three assessments of motor performance: the FMA, the Stroke Impact Scale (SIS; Carod-Artal, Coral, Trizotto, & Moreira, 2008; Duncan, Lai, Bode, Perera, & DeRosa, 2003; Duncan et al., 1999), and the Canadian Occupational Performance Measure (COPM; Law et al., 1998). The FMA is a quantitative measure of motor recovery, balance, sensation, coordination, and speed. Extensively applied with stroke clients, it is based on the principle that motor recovery occurs in a predictable progression (Gladstone et al., 2002). The FMA has high interrater reliability (.886–.984) and test–retest reliability (.99; Duncan, Propst, & Nelson, 1983). We administered the UE motor control portion of the FMA, which has a possible total score of 66 points.

The SIS is a participant self-report that uses a Likert scale to assess hand strength, function, mobility, activities of daily living and instrumental activities of daily living, memory and thinking, communication, emotion, and participation. It also includes a percentile scale to assess the participant’s perception of how much recovery has occurred. It has reliable psychometric attributes, including reliability (correlation coefficients ranging from .70 to .92) and validity (correlation coefficients ranging from .82 to .84). We administered all portions of the SIS.

The COPM is a subjective quality-of-life measure that uses a 10-point scale on which clients score their own occupational performance, as well as their satisfaction with performance, in relation to as many as five self-selected tasks. In this way, the COPM reveals tasks that therapists may use to support clients’ return to meaningful roles. The COPM is completed in an interview format and is designed to create a client-centered intervention. With a population with stroke, the COPM had high test–retest reliability for performance scores (.89, p < .001) and satisfaction scores (.88, p < .001), and its discriminant validity has been established (Cup, Scholte op Reimer, Thijssen, & van Kuyk-Minis, 2003). When working with people living in the community, McColl, Paterson, Davies, Doubt, and Law (2000) found that the COPM had moderate construct validity and high community utility. We administered all portions of the COPM.

Neurophysiological assessments. For this project, we used TMS to measure changes in resting motor threshold (rMT) and cortical motor map. TMS delivers noninvasive brain stimulation via a handheld coil that uses a rapidly changing magnetic field to activate pyramidal neurons. The rMT is a measure of neuronal membrane excitability. In this study, we defined rMT as the minimum TMS intensity (measured to the nearest 1% of maximum stimulator output) required to elicit motor-evoked potentials (MEPs) of ≥50 μV

Table 1. Results on the Fugl-Meyer Assessment (FMA) and Stroke Impact Scale (SIS)

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Baseline</th>
<th>Postintervention</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>FMA: upper-extremity motor control</td>
<td>40</td>
<td>53</td>
<td>13</td>
</tr>
<tr>
<td>Summary of domains</td>
<td>53.3</td>
<td>68.4</td>
<td>15.1</td>
</tr>
<tr>
<td>Hand strength</td>
<td>13</td>
<td>16</td>
<td>3</td>
</tr>
<tr>
<td>Activities of daily living and</td>
<td>52</td>
<td>57</td>
<td>5</td>
</tr>
<tr>
<td>instrumental activities of daily</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>living</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mobility</td>
<td>45</td>
<td>49</td>
<td>4</td>
</tr>
<tr>
<td>Hand function</td>
<td>10</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Memory</td>
<td>26</td>
<td>36</td>
<td>10</td>
</tr>
<tr>
<td>Communication</td>
<td>34</td>
<td>28</td>
<td>–6</td>
</tr>
<tr>
<td>Emotion</td>
<td>35</td>
<td>41</td>
<td>6</td>
</tr>
<tr>
<td>Participation</td>
<td>52</td>
<td>57</td>
<td>5</td>
</tr>
</tbody>
</table>
in at least 5 of 10 consecutive trials (Rossini & Carema, 1988). Cortical motor mapping measures cortical representation of a given muscle (Liepert et al., 1998; Wassermann, McShane, Hallett, & Cohen, 1992). To measure cortical map change, we calculated change in the normalized map volume (nMV) and the center of gravity (COG). The nMV is a simple measure of the spread of the motor representation over multiple scalp sites. The COG is an average of all active location vectors, each weighted by the MEP amplitude at that location (Wassermann et al., 1992). If there are N locations, the COG is calculated by

$$\text{COG} = \frac{\sum_{i=1}^{N} (x_i \cdot n_{MEP})}{n_{MV}}$$

for the x coordinate (COGx) and similarly for the y coordinate (COGy; Liepert et al., 1998).

To perform TMS assessments, we placed monitoring electrodes over the belly of the extensor digitorum communis (EDC) muscles bilaterally. We selected the EDC muscle because it is the primary effector of finger extension and has been extensively studied in multicenter longitudinal studies evaluating the effects of intervention in stroke motor recovery (Sawaki et al., 2008). To ensure reproducibility of electrode placements at different time points, we created a plastic film template of the dorsal surface of the participant’s forearm. We continuously monitored relaxation of the target muscle by means of visual electromyographic (EMG) feedback and delivered TMS using a Magstim 200 stimulator fitted with a figure-eight coil (Magstim, Whitland, Dyfed, Wales). With the coil at the frontoparietal region optimal to elicit the motor response, we delivered rMT and stimulation at a rate of 0.2 Hz to various sites on the scalp using Magstim 200. To ensure reproducibility of electrical MEPs on the contralateral EDC, we triggered TMS using a Magstim 200 stimulator while the participant wore a tight-fitting, flexible cap (Electro Cap International, Eaton, OH) and monitored the spread of the motor representation over multiple scalp sites. The COG is an average of all active location vectors, each weighted by the MEP amplitude at that location (Wassermann et al., 1992). If there are N locations, the COG is calculated by

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course of the intervention. Improvement occurred in all SIS domains except communication. The most notable increase in SIS scores occurred in the domains of hand function and memory.

Table 3 summarizes COPM data. These data indicate that Will perceived improvement in both occupational performance and satisfaction with performance. He reported a greater magnitude of change in his satisfaction than in his performance.

Neurophysiology (Neuroplastic Change)

No notable difference existed between rMT at baseline (47% of maximum stimulator output) and rMT at postintervention (54% of maximum stimulator output). We noted a considerable bilateral increase in cortical motor map volume postintervention (Figure 1). More specifically, the contralesional motor map volume changed from 3.28 at baseline to 9.38 at postintervention (measured normalized MEP × cm²), and the ipsilesional motor map volume changed from 0 at baseline (indicating absence of MEPs) to 0.22 at postintervention. We observed no notable changes in contralesional COGx (3.66 cm at baseline; 3.68 cm at postintervention). Contralesional COGy moved posteriorly (−0.16 cm at baseline; −1.05 cm at postintervention).

Description of Participation in Occupation

As intervention progressed, Will reported several changes taking place. More specifically, he reported increased motivation, increased confidence, increased component factors of affected UE function (including improved proprioceptive awareness), improved self-management of health routines (e.g., knowledge of effective stretching, pain management, and self-cueing supporting bilateral UE use), increased role competence, and increased self-direction in occupational performance. Table 1 provides additional details of Will’s descriptive results.

Discussion

The results of this case study indicate that a relatively brief period of occupation-based intervention in a hospital setting designed to simulate a home environment...
considerably enhanced affected UE motor recovery, neuroplastic change, and occupational performance for 1 participant with chronic stroke. Will’s FMA change in UE motor control exceeded the threshold for clinically meaningful change, which research has established as 3 points (Lo et al., 2010). Likewise, the changes in SIS scores for the summary of all domains, as well as the hand function domain, met or exceeded the threshold (10–15 points change) for clinical relevance (Duncan et al., 2003). Will’s SIS measurement of perceived overall recovery showed a notable gain as well. Because a COPM change of ≥2 points reflects clinical relevance (Law et al., 1998), Will’s COPM change showed that he experienced clinically meaningful effects with regard to occupational performance and satisfaction. Likewise, the descriptive outcomes reflect that Will experienced positive change in both occupational profile and occupational performance, ultimately improving his health and well-being.

Neurophysiological evaluations also reflected marked improvement since baseline. As a result of intervention, Will exhibited not only expansion of the contralesional motor map but also the first-time emergence of ipsilesional MEPs. The initial emergence of MEPs on the ipsilesional brain after intervention, at which time Will was 18 mo poststroke, strongly indicates an association of ipsilesional neuroplastic change with intervention. That motor map expansion occurred in the absence of notable changes in rMT indicates that nonspecific changes in corticomotor excitability are not likely to have confounded the interpretation of map area changes. Either or both of the following points may explain why corticomotor reorganization occurred bilaterally:

- Intervention entailed bimanual tasks, which may have led to neuroplastic change related to each UE (rather than the affected UE only).
- Because stroke can unmask the 10% of the corticospinal tract that remains uncrossed, intervention could affect this normally latent tract, in which case the results of intervention would not be restricted to ipsilesional (i.e., unilateral) neuroplastic change.

Limitations of this study affect the generalizability of our findings. First, evidence from a single case study cannot be generalized (Sackett, Rosenberg, Gray, Haynes, & Richardson, 1996). However, single-case studies have value in that they can provide preliminary evidence for, as well as detailed descriptions of, specific interventions and outcomes. Second, one could argue that the inclusion of preparatory methods and purposeful activity as ancillary techniques to occupation-based intervention may have confounded this study’s results. However, we believe that regarding these ancillary techniques as constituent parts of or necessary precursors to occupation-based intervention is justifiable. This viewpoint necessitates ensuring that the recipient of intervention understands the essential connection between the preparatory method or purposeful activity and the occupation (Price & Miner, 2007). Notably, this approach helped facilitate the participant’s engagement in the occupation of managing preparatory health-related habits and routines (i.e., self-stretching and spasticity reduction) for enhancing general occupational performance outside the study.

### Implications for Occupational Therapy Practice

This evidence demonstrates that TMS is a viable tool to measure results of occupation-based intervention and to build the occupational therapy evidence base. Moreover, this case report shows that occupation-based intervention can support adaptive rewiring of the brain and improved occupational performance.

### Conclusion

In 1 participant with chronic stroke, a restorative approach to occupation-based intervention led to enhanced occupational performance, resumed competence in desired roles, improvement in affected UE functional use, and notable neuroplastic change as measured by TMS. To build on this study, we recommend future large-scale study.

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**Table 3. Results on the Canadian Occupational Performance Measure**

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Performance</th>
<th></th>
<th></th>
<th>Satisfaction</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Postintervention</td>
<td>Change</td>
<td>Baseline</td>
<td>Postintervention</td>
<td>Change</td>
</tr>
<tr>
<td>Managing fasteners</td>
<td>1</td>
<td>6</td>
<td>5</td>
<td>1</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Opening containers</td>
<td>1</td>
<td>6</td>
<td>5</td>
<td>1</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Tying trash bags, shoelaces</td>
<td>1</td>
<td>9</td>
<td>8</td>
<td>1</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Folding towels</td>
<td>1</td>
<td>6</td>
<td>5</td>
<td>1</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Playing guitar</td>
<td>1</td>
<td>7</td>
<td>6</td>
<td>1</td>
<td>10</td>
<td>9</td>
</tr>
</tbody>
</table>
studies comparing behavioral, neurophysiological, and descriptive outcomes of various occupational therapy approaches for recovery from various levels of post-stroke motor deficit (i.e., mild, moderate, or severe). In addition, we recommend that such studies incorporate a longer follow-up period. ▲

Acknowledgment

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References


