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Hemiparetic Optimal Practice and Evaluation (H.O.P.E.) for the Stroke Survivor with Very Low Hand Function

Valerie Carter

Purpose: The purpose of this study is to describe an approach that may benefit persons with severe hemiparesis following stroke. **Method:** The subjects were 3 stroke survivors who had experienced a stroke that left their dominant right extremity severely disabled (mean age 43 years, mean time since stroke 26.6 months, mean Fugl-Meyer UE motor score 14.3/66). A multiple baseline, preintervention-postintervention case series design was used. The intervention consisted of structured whole body, increased intensity, activity-dependent practice strategy, with 3 to 5 sessions lasting for more than 3 hours per day, for 1–5 weeks for an average of 170 hours of therapy over 2.5 years. Subjects completed therapies such as body weight-supported treadmill training, overground multidirectional gait training, balance retraining, upper extremity functional activity, and trunk and extremity mobility. **Results:** The subjects experienced decreased fall risk (mean Timed Up and Go [TUG] scores decreased from 14.9 s to 6.8 s) and improved community safety (mean speed of gait in 10 m improved from 18.3 s to 8.3 s) and decreased impairment level as measured by the Fugl-Meyer Assessment (FMA: mean UE motor score from 14.3/66 to 53/66). Finally, subjects demonstrated an increase in their hemiparetic UE functional ability (mean amount of tasks completed in the Wolf Motor Function Test [WMFT] from 3.6/15 tasks to 15/15 tasks) following the intervention. **Conclusion:** The findings indicate that hemiparetic optimal practice and evaluation (H.O.P.E) rehabilitation led to a decrease in the level of impairment along with a corresponding increase in function of the severely hemiparetic arm. The outcomes are significant: few treatment approaches have demonstrated an increase in the function of the severely affected arm in this population. **Key words:** *hemiparesis, low function, stroke, neuroplasticity, rehabilitation*

In the United States, a stroke occurs every minute and death from stroke every 3.5 minutes. Those who survive an ischemic or hemorrhagic stroke suffer some permanent disability, which can be catastrophic. Currently there are an estimated 4.6 million stroke survivors living in the United States, many of whom suffer from severe upper extremity disability. Stroke is the leading cause of major disability in older Americans, and patients with stroke are the largest consumer of rehabilitation services.^{1–3} Despite widespread acceptance of physical rehabilitation services and billions of dollars spent annually for its use in patients with stroke, studies examining the efficacy of these services have shown limited value.⁴

Research studies have consistently reported findings that suggest that stroke survivors with the sensorimotor potential to achieve hand dexterity on the affected side should receive every opportunity to participate in restoration-based therapies. In contrast, the approach for patients who demonstrate a poor prognosis for recovery is to focus treatment on achieving function through the primary use of compensation strategies.^{5–9} This

approach is likely grounded in a lack of clinical evidence supporting the efficacy of restorative-based treatment strategies to achieve function in patients with severe sensorimotor upper extremity (UE) impairments following stroke.

Fortunately, it is now well known that after injury to the central nervous system the brain has the ability to create positive cortical reorganization and improve function spontaneously as well as from responses to structured, high-intensity activity-dependent practice.^{10–17} Approaches to UE rehabilitation such as constraint-induced movement therapy (CIMT) and modified CIMT^{18–24} have been shown to be effective for the stroke survivor with a higher functioning UE. However, stroke survivors with a low functioning

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hemiparetic UE²⁵ will not meet the typical inclusion criteria for CIMT therapy, which involves the ability to complete some wrist and finger extension. This requirement may be the result of studies that have shown that the current models of CIMT and modified CIMT have not been effective at promoting the restoration of function to a more severely involved hand.²⁶⁻²⁸ Bonifer and Anderson administered CIMT to a patient who initially exhibited no isolated wrist movement and reported some motor changes but no functional benefits.²⁹

Because it is well documented that, along with the severity of stroke, severe extremity paresis is a direct predictor of poor functional outcomes and severe disability,⁴⁻⁹ the development of an effective practice approach for persons with severe UE hemiparesis may give hope to these individuals.

This series of case studies will introduce an approach that has shown promise as a treatment for stroke survivors with severe UE hemiparesis. This full-body approach to rehabilitation combines increased intensity of goal-directed exercise, activity-dependent / problem-solving practice strategies, and appropriate ongoing evaluation measures to create an optimal blend of comprehensive rehabilitation for the individual with the lowest functioning hemiparetic UE. This strategy, called hemiparetic optimal practice and evaluation (H.O.P.E.), has resulted in an improved outlook and quality of life for the subjects in this study.

Method

A multiple baseline, preintervention-postintervention case series design was used. Patients were treated in a clinical setting at South West Advanced Neurological (SWAN) Rehabilitation in Phoenix, Arizona, or at Northern Arizona University in Flagstaff, Arizona, in a summer neurological clinic between 2002 and 2005.

Case study overview

The three subjects in this study represent the many individuals (approximately 60) who have received this form of rehabilitation at our clinics between 2002 and 2005. Each of the three subjects had sustained a cerebrovascular (CV) event with subsequent severe right hemiparesis. All three individuals reported good general health prior to their CV event.

The subjects included G.M., a 51-year-old former security guard who began his H.O.P.E. rehab in 2000, 5 years post stroke; S.N., a 48-year-old nurse who began her H.O.P.E. rehab 10 months post stroke, which occurred in 2003; and L.V., a 30-year-old woman who worked in public relations and marketing and began her H.O.P.E. rehab 10 months post stroke, which occurred in 2001 (see **Table 1**). All three subjects were unable

Table 1. Patient demographics

Patient	G.M. Left CV event Right hemiparesis	S.N. Left CV event Right hemiparesis	L.V. Left CV event Right hemiparesis
Age on evaluation date	51 years	48 years	30 years
Marital status	Married	Married	Married
Current job status	On disability (former security guard)	UR nurse (32 hr/wk, former floor nurse)	On disability (formerly in marketing and management)
Time since stroke	5 years	10 months	10 months
Amount of time since outpatient rehabilitation	4.5 years	1 week	2 months
Prestroke hand dominance	Right hand dominance	Right hand dominance	Right hand dominance
Hand most commonly used post stroke	Left hand	Left hand	Left hand
Housing	Single-family home	Single-family home	Single-family home

Note: CV = cerebrovascular; UR = utilization review.

Table 2. Outcome results

Measure	G.M.		S.N.		L.V.	
	pre	post	pre	post	pre	post
WMFT	87 s	3 s	117 s	5 s	101 s	6 s
Avg. task time						
Amount of tasks completed in 120 s	5/15	15/15	2/15	15/15	4/15	15/15
Grip strength	4.6 lbs.	15.1 lbs.	Unable	8.5 lbs.	3.2 lbs.	10.7 lbs.
Fugl Meyer UE scores	14/66	58/66	12/66	52/66	17/66	49/66
Berg Balance Scale	51/56	56/56	46/56	56/56	49/56	53/56
Functional Gait Assessment	24/30	30/30	22/30	30/30	NT	29/30
10-meter walk test	17.3 s	5.9 s	19.6 s	5.7 s	17.9 s	13.3 s
Timed Up and Go (regular)	14.8 s	5.2 s	15.4 s	6.9 s	14.4 s	8.3 s
6-minute walk test	1040 ft	2080 ft	720 ft	1695 ft	795 ft	1222 ft

Note: WMFT = Wolf Motor Function Test; UE = upper extremity; NT = not tested initially.

to use their right hand for any functional activities post stroke, and each individual wished to regain some function of the right hand.

Outcome tools

The measure of motor performance used in this study was the Fugl-Meyer Assessment (FMA). The FMA is an ordinal scaled cumulative assessment that measures motor recovery relative to the extent of quality of synergic movements.³⁰ The FMA is based on the premise that motor recovery occurs in a predictable progression. The UE overall total score consists of the combined sensation, joint range of motion, and pain scale scores (0–126 points). The estimated intratester reliability for all subsections and total scores of the FMA were found using a repeated-measures analysis of variance (ANOVA) and Pearson correlation coefficients.³¹

A measure of functional performance use in this study was the Wolf Motor Function Test (WMFT), which consists of 15 timed and two strength activities and is ordered from simpler to more complex tasks (i.e., lift arm to table to stack three checkers). Wolf et al. report interrater reliability and validity as comparable to the FMA.³²

Other measures of functional performance include the Timed Up and Go (TUG), Berg Balance Scale, Functional Gait Assessment, 10-meter walk test, and 6-minute walk test (see **Table 2**).

Interventions

The H.O.P.E. technique applies accepted principles of motor learning (the appropriate amount of feedback and practice structure) and experience-dependent neural plasticity (involving task specificity, repetition, graded intensity, timing, and practice)³³ to promote optimal learning and recovery. The practice principles also included application of unimanual and bimanual UE task practice,²⁷ manual and weighted resistance, and body weight-supported treadmill training (BWSTT). Many of these techniques are proven to be effective in the rehabilitation of stroke survivors.^{34–36} The use of these interventions was adapted to the needs of each subject (see **Table 3**). The three subjects participated in an average of 170 total treatment hours involving these interventions. The treatment sessions were spread over the course of 2.5 consecutive years between 2002 and 2005.

The H.O.P.E approach emphasizes task-specific functional movements. Winstein et al. stated that a task is best understood by the brain when presented in a functional context.³⁷ Wolf et al. also reported on the type and quality of functional task practice; they suggested that in addition to the unilateral approach of CIMT recovery of function may also be enhanced through bilateral functional task practice and that most likely both unimanual and bimanual forms of UE task practice are needed for optimal functional recovery.²⁷

Table 3. H.O.P.E. rehabilitation intervention list

Activities	Mat activities (1 hr/treatment session)	Functional activities (1–2 hr/treatment session)	Gait and balance activities (1 hr/treatment session)
	Proprioceptive neuromuscular facilitation (PNF) techniques	Unimanual tasks	Assistive gait training
	Resistive diagonal patterns of extremities	–scoop/pour	Manual resistive gait training
	Resistive diagonal patterns of pelvis and scapula	–shuffleboard push	Pulley resisted gait training
	Joint approximation	–close chain push/pull	Multidirectional gait training
	Resistive rolling and bridging	–counter/wall scrub	–side stepping
	Trunk disassociation	–pronation/supination (functional tasks)	–backwards stepping
	–low trunk rotation	–fine motor functional tasks (pennies, checkers, bolt lift and pull from clay)	–front stepping
	–side-lying upper trunk rotation	–throwing	–braiding
	Trunk stabilization techniques	–reach and lift	–heel to toe walking foreword/backward
	–all 4s rocking with resistance	–placing blocks in container with hand position of neutral, prone, or supination	–up and down inclines
	–prone alternating arm/leg lift	–racket activities	BWSTT
	–all 4s alternating arm/leg lift	Bimanual tasks	–progress toward more speed and less support
	–plank on elbows	–basket lift	High-level balance activities
	–plank on hands	–folding clothes	–tandem stance (and hit a balloon)
	–bridge over ball	–close chain scrub (wall/counter)	–single leg stance (kick ball)
	Transition training	–push/pull	–step ups/downs (while reaching)
	–prone on elbows, all 4s	–carrying tasks	–squat work with pulley resistance
	–tall kneeling, half kneeling to standing, and reverse with resistive diagonals of trunk, neck, and/or extremities in each position (isometric resistance in each posture)	–hand to hand tasks	–touch toe in clock pattern with pulley resistance
		–large ball throws	
		–zoom ball	

Note: All activities are modified for safety and success. Modification of activities could include adding harness support for single leg stance or ball-kicking activities; use of ace wrap to assist involved hand to hold racket or baton, etc.; placement of dynamic taping or plastic ring device to extend fingers and maintain thumb in opposition; and position hand into wrist and finger extension for dynamic weight-bearing activities, i.e., spread clay with involved extremity from modified plantar grade position. BWSTT = body weight-supported treadmill training.

Results

At the time of the initial evaluation, each of the three subjects was able to ambulate independently. Their overall balance and gait speed test scores placed them at a slight risk for falls (mean TUG scores of 14.9) due to decreased ambulation speeds and decreased community mobility safety (mean 10-meter walk test time 18.3; <80 cm/s). During the initial evaluation, the UE FMA was completed along with the WMFT. All three subjects had difficulty completing many of the 15 WMFT tasks (mean number of WMFT completed = 3.6/15) and scored very low on the UE motor portion of the FMA (mean score of 14.3/66; see **Table 2**). Following three to five intensive bouts of H.O.P.E. rehabilitation lasting 1 to 5 weeks, each subject demonstrated normal fall risk along

with increased ambulation speeds, which resulted in increased community mobility safety. Most remarkably, each of their UE scores on the FMA and the WMFT changed from severely involved to minimally involved. This was reflected in their ability to complete all of the 15 WMFT tasks and to achieve an average score of 53/66 on the FMA (see **Table 2**). All three of the subjects reported improved quality of life in that they were able to return to recreation such as four-wheel driving in the desert (G.M.), wearing high-heeled shoes and dancing with her husband (L.V.), and tending to and riding the family's horses (S.N.).

Discussion

Stroke is a leading cause of disability among adults in developed countries. Any treatment that

improves functional outcome can significantly reduce the impact of this condition on the individual, the family, and society.¹ Rehabilitation is a recognized cornerstone of multidisciplinary stroke care. Yet traditional stroke rehabilitation as well as methods such as CIMT and modified CIMT have not proven to be effective in improving the quality of life for stroke survivors with very low hand and arm functioning. Reduced UE function is a key factor in lower quality of life outcomes.³⁸ Because grasping, holding, and manipulating objects require the recruitment and complex integration of muscle activity from shoulder to fingers, impairments in these tasks persist in a majority of stroke survivors. Four years after stroke, many survivors report the loss of the arm function as a major problem, even though 96% reach independence in activities of daily living as reflected by their Barthel Index scores. Persistent reliance on one side of the body may create an additional disability resulting from painful overuse syndromes.³⁹

The psychological and emotional consequences of UE impairment in stroke are significant. All three subjects expressed deep anxiety and frustration associated with looking “abnormal” while at work, in restaurants, and out in the community in general. Although each of the subjects enjoyed the support of their family and friends (a factor that is related to better outcomes in individuals with CV events),³⁹ their embarrassment at being viewed as abnormal contributed to a decline in their social interaction and consequent feelings of depression and isolation.

The three subjects in this study had positive outcomes following H.O.P.E. rehabilitation with relatively similar time and costs (compared to traditional approaches) over a 2.5-year period. The average amount of time spent for the three patients was 170 hours over 2.5 years or the equivalent of 7 months of traditional outpatient rehabilitation (involving 3 one-hour sessions of physical therapy and occupational therapy per week, for a total of 168 hours). An increased quality of life was reported by spouses, other family members, and the three subjects, therefore the case study participants are more likely healthier and less depressed. This study suggests that replacing the traditional methods and delivery of outpatient

rehabilitation with this short-term intensive therapy might ultimately prove more cost effective and reduce insurance expenditures with superior lasting results for persons with CV events.

The results of this study suggest that the lower level hand can benefit from this whole-body intense practice. The duration of this benefit may vary between patients. For example, S.N. required less than half of the amount of therapy time as G.M. or L.V. to improve functional ability, even though the HOPE treatment process was similar throughout. It is possible that compared to the other two subjects, S.N. may have had less cellular death from the CV event along with what is known as a “diachisis effect,”⁴⁰ the temporary inhibition of healthy brain tissue post stroke, which often responds to functional intervention. Days before the beginning of her H.O.P.E. training, S.N. had been discharged from traditional outpatient occupational therapy and physical therapy due to lack of progress. However, within the first 2 days of H.O.P.E. rehabilitation, S.N. began to demonstrate individual finger, wrist, elbow, and shoulder movements. One possible explanation is the activities in her traditional rehabilitation may not have been at the intensity levels necessary to provoke function-enhancing cortical responses. Thus, H.O.P.E. rehabilitation may more effectively allow for the clinical application of the neuroplasticity principles¹⁷ necessary to drive functional recovery.⁴⁰

The average age of the stroke survivors in this case study was 43 years old. However, Kugler et al. reported that older stroke survivors have similar potential for functional recovery as younger ones.⁴¹ H.O.P.E. rehabilitation has been useful for patients ranging from 3 years to 96 years of age. It has also been effective for patients with head injury, cerebral palsy, central cord syndrome, incomplete spinal cord injury, and other CNS conditions.

Although many quality outcome tools were utilized during this study, other instruments such as the Stroke Impact Scale (SIS) may have been beneficial and are now being used for patients who complete H.O.P.E. rehabilitation. The SIS has been developed as a more comprehensive measure of health outcomes for the stroke population and is able to measure changes in emotion. Duncan et al. have shown the SIS to have less ceiling and

floor effects and to be valid, reliable, and sensitive to change when compared with other commonly used measures such as the Barthel Index and Short Form-36 in individuals with stroke.^{42,43} The outcomes measures used in this study were selected specifically to assess changes in balance, gait speed, endurance level, UE use, and recovery level as well as functional ability. Current H.O.P.E. trials are examining the impact of therapeutic intervention on subjects' self-selected gait speed in the hope that related improvements will facilitate safe, community mobility.

Conclusion

This article has investigated an evidence-based restorative rehabilitation approach that can improve function of the stroke survivor with severe UE arm paresis. H.O.P.E. rehabilitation combines

increased intensity, goal-directed, activity-dependent/problem-solving practice strategies and appropriate ongoing evaluation measures to create an optimal blend of comprehensive rehabilitation for the majority of stroke survivors. The three stroke survivors in this case study demonstrated improvements in gait, balance, and UE functional abilities, which improved their quality of life. H.O.P.E. may indeed promote a more optimistic outlook for stroke survivors.

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