Whole-Body Intensive Rehabilitation Is Feasible and Effective in Chronic Stroke Survivors: A Retrospective Data Analysis

Kay Wing, James V. Lynskey, and Pamela R. Bosch

Purpose: Upper extremity (UE) intensive repetitive training, locomotor training, and functional strength training, delivered in isolation, promote neural plasticity and functional recovery after stroke. However, the effectiveness of a comprehensive whole-body approach combining these interventions has not been thoroughly investigated. The purpose of this retrospective data analysis was to evaluate the efficacy and feasibility of intensive, comprehensive rehabilitation for a heterogeneous population of chronic stroke survivors in a community clinic setting. **Method:** Whole-body intensive rehabilitation (3–6 hours/day, 4–5 days/week, ≥2 weeks) consisted of locomotor, balance, and transfer training; progressive resistive strengthening exercise; and repetitive task-specific UE practice. Outcome measures were collected from all patients participating in the program between March 2003 and January 2008 who were diagnosed with a stroke ≥12 months prior to treatment initiation (N = 35). **Results:** Significant improvements in function were observed as measured by the Fugl-Meyer Assessment, Wolf Motor Function Test (WMFT), Box and Block test, Berg Balance Scale, Timed Up & Go Test (TUG), and 6-minute walk test. **Conclusion:** Whole-body intensive rehabilitation is an effective and feasible approach to promote recovery in chronic stroke survivors with moderate to severe deficits. Further research is necessary to confirm these results in a more controlled environment. **Key words:** *cerebrovascular accident, chronic, comprehensive, function, intensive, recovery, rehabilitation, stroke, training*

Cerebral vascular (CV) events are the leading cause of disability for adults in the United States. The number of new cases approaches several million annually; with millions of survivors being left with social, motor, and/or mobility deficits. The result is a compromised ability to perform activities of daily living and a diminished quality of life for both the survivors and their caregivers. This comes at a cost of millions of dollars annually. A vast amount of research has been conducted over the last 20 years that has demonstrated the effectiveness of various rehabilitative interventions in promoting recovery of function and plasticity after CV events in both humans and animals.[1,2] However, most of these studies have focused on highly specific interventions in discrete subpopulations of stroke survivors, leading to a gap between this research and clinical practice. The purpose of this retrospective data analysis was to evaluate the efficacy of intensive, comprehensive therapy delivered in a community clinic setting.

The potential for enhancement of neural plasticity and sensorimotor recovery through the use of intensive and repetitious training has been clearly demonstrated after cortical injury in both humans and animals.[3] Training-dependent changes in cortical organization and excitability have been termed *activity-dependent plasticity*, and evidence exists that this plasticity is an underlying mechanism mediating activity-dependent recovery of function after cortical injury.[4–9] Furthermore, research has shown that the timing of intervention, type of training, and intensity of training all appear to play critical roles in determining the extent of recovery and plasticity.[10–13] In addition, repetition, task complexity, task difficulty, and task specific-

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ity are all necessary components for neuroplastic changes.[3,9,12–22]

Therapeutic interventions based on the critical nature of repetition and intensity, as described previously, have been studied in isolation for upper extremity (UE) and locomotor recovery. Approaches to promote recovery of UE function after CV events that have been investigated include constraint-induced movement therapy (CIMT), bimanual training, robotic training, and task training with functional electrical stimulation (FES) assist. Data from multiple studies indicate that each of these interventions can effectively improve recovery when delivered in isolation.[15,23–26] Some of these interventions have even been shown to promote cortical reorganization.[13,27,28] However, interventions like CIMT have focused on a limited patient population, specifically acute, subacute, or chronic stroke survivors with mild to moderate deficits.[23,29]

Similarly, the effects of different locomotor training paradigms on recovery of locomotion after CV events have also been investigated. Numerous studies show that locomotor training on a treadmill (TM), locomotor training on a treadmill using body weight support (BWSTT), and locomotor training using electrical stimulation have been more effective than conventional therapy alone for improvement of balance, motor recovery, gait velocity, and endurance.[30–33]

Research has also shown that CV event-associated losses in strength, which contribute to reduced walking speed and endurance, decreased UE function, and general impairment in motor performance, are not inevitable.[34] Strength training to targeted muscles can limit the impact of weakness and its disabling consequences. Strength gains are important for appropriate force production in response to task demands. It has been shown that gains can be made in basic activities of daily living (ADLs) such as walking speed, sit to stand transfers, bed mobility, and certain UE activities after a progressive resistive exercise program.[35]

Thus, it is clear that in the research laboratory setting UE function, locomotor ability, and strength can all be improved by specific interventions after CV events. It is important to note, however, that although these various training models have yielded significant improvements in function, none of them were designed to be delivered in a community clinic or to address the cascade of stroke-related neuromotor impairments in a comprehensive manner. Furthermore, many of these studies have primarily investigated unique techniques applied to higher functioning chronic and/or acute stroke survivors, which comprise the minority of patients seen in many stroke rehabilitation programs.[15,29] Hence, there is a need for studies to evaluate the effectiveness of comprehensive interventions that can be realistically implemented in the current practice environment and applied to a heterogeneous population of stroke survivors. The clinical data presented in this paper indicate that an intensive, integrative (whole body) model of rehabilitation based on current scientific knowledge is applicable and practical for moderate to severely impaired chronic stroke survivors in a community clinical practice.

Method

Participants

This study involved retrospective chart reviews of 71 patients who were treated between March 2003 and January 2008 in an outpatient neurorehabilitation facility. Thirty-five of these patients' charts met the inclusion criteria and were included in the study. All patients were individuals who had sought treatment at the outpatient facility and were receiving the care typically given at the facility. Reimbursement by insurance companies was typical among the population.

The sample of participants included 21 men and 14 women, with an average age of 60.2 ± 14.1 years and a range of 31 to 86 years (**Table 1**). Fourteen participants had sustained a left CV event

Table 1. Descriptive characteristics of 35 participants (14 females)

	Mean (*SD*)	Range
Age in years	60.2 (14.1)	31–86
Months post-CV event	40.9 (29.1)	12–123
Total days of treatment	16.6 (3.8)	8–25
Total hours of treatment	72.7 (21.2)	35–117.75
Hours of treatment per day	3.8 (1.0)	2.6–6.0

Note: CV = cerebrovascular.

Table 2. Typical 3- and 6-hour therapy schedules

Sample 3-hour schedule		Sample 6-hour schedule	
8:30–9:30	Gait training	8:30–9:30	Repetitive task practice
9:30–10:30	Repetitive task practice	9:30–10:30	Gait training
10:30–11:00	Strength training	10:30–11:30	Mat therapeutic exercise
11:00–11:30	Mat therapeutic exercise	12:30–1:30	Strength training
		1:30–2:30	Repetitive task practice
		2:30–3:30	Repetitive task practice

with right hemiparesis, and the other 21 had a right CV event with left hemiparesis. This was the first stroke for all participants. The range of time post stroke was 12 to 123 months, with an average of 40.9 ± 29.1 months post stroke (**Table 1**).

To be included in this analysis, each patient was required to have a diagnosis of CV event, to be at least 1 year post CV event, and to be currently undergoing a whole-body intensive program under the supervision of the authors. This rehabilitation program involved an intensity of at least 3 hours per day, 4 days per week, for a minimum of 2 weeks.

Intervention

The intensive therapy received by each patient was individualized to the patient's deficits but included the following: (a) BWSTT, overground gait training, dynamic balance training, and transfer training; (b) progressive resistive strengthening exercise (PRE) of the trunk and all four extremities; and (c) task-specific practice to improve shoulder, arm, and hand function.

Patients were challenged with increasing demands throughout their therapies, that is, faster speeds, longer distances, more weights/resistance, or increased fine motor movements. Patients typically participated in a full-day (6 hours, n = 27) or a half-day (3 hours, n = 8) program. **Table 2** illustrates a typical patient schedule.

Intervention progression

Progression of gait and balance activities included the following guidelines. All patients were trained with BWSTT, as well as overground gait training, with each session consisting of one or both interventions. During BWSTT, the amount of body weight support and manual assistance was reduced as necessary for safe ambulation without an orthosis. As patients progressed, the number and length of rest periods were also decreased. In addition, the patient's speed was increased from his/her baseline rate to at least 0.8 m/s (1.8 mph) as tolerated to approximate a slow community walking speed.[36] The increases in speed along with decreases in the number and/or duration of rest periods led to an increased number of steps and longer distances. Overground walking was conducted both indoors and outdoors on a variety of surfaces including ramps, curbs, steps, and grass. Training emphasized kinematics of equal stride length, weight shift, cadence, and arm swing. A 6-minute overground walk test was conducted periodically to assess gait speed and endurance. Balance was challenged with balance disks, rocker boards, obstacle training, and the use of pulleys. In addition, balance was trained simultaneously with gait training because ankle strategies were recruited when walking on various surfaces and obstacle courses.

Progression of UE functional tasks was based upon individual responses to activities. As a participant's performance improved (along with decreases in fatigue, frustration level, and assistance), tasks were made more challenging. This was accomplished through various mechanisms, including increasing the complexity of a task, decreasing the amount of time to complete a task, reducing body support, or moving activities farther away from the participant. Activities were chosen that incorporated all UE movement patterns to the extent possible (shoulder flexion/abduction, shoulder internal/external rotation, elbow flexion/extension, forearm pronation/supination, wrist flexion/extension, and hand/finger fine motor control). Assistance and facilitation were provided as needed for the patient to be successful and reduce substitution. Many activities were timed to encourage speed and to increase the number of repetitions performed during each treatment session. For example, one activity involved having the patient pull pegs out of a Peg-Board from a table, countertop, floor, or a cupboard. Patients could perform the task in various positions, such as sitting, standing, prone on elbows, or side sitting, to alter the demands of the task. Similarly, the pegs could vary in size, shape, and weight. The pegs could be released onto the table, into a bowl, or into a slotted box, at various heights.

Outcome measures

The Fugl-Meyer Assessment (FMA) was used to assess fine and gross motor skills, range of motion, pain, proprioception, and sensation. The FMA is widely used in both clinical and research settings and is a reliable and valid tool for assessing both sensory and motor function in stroke patients.[37] Increased scores reflect improvements in each component tested.

The Wolf Motor Function Test (WMFT) was used to assess UE function. The WMFT is a tool that includes seven timed, single-joint segment motions and eight timed integrative functional UE tasks.[38,39] The WMFT is commonly used in research involving CIMT and has been demonstrated to have high interrater reliability (.97 for performance time, .88 for functional ability), internal consistency (.86–.92 for performance time, .92 for functional ability), and test–retest reliability (.90 for performance time, .95 for functional ability).[39] Decreases in time to complete tasks are equated with improvements in motor function.

Grip and pinch strength tests were used to measure the muscular strength of the hand and fingers respectively. There is a strong correlation between grip strength and overall upper body strength.[40] Both a Jamar™ hydraulic hand dynamometer and Jamar™ hydraulic pinch gauge were used (JLW Instruments, Inc., Chicago, IL).

The portable Box and Block kit (Sammons Preston Roylan Canada, Inc., Ontario, Canada) was used to test UE manual dexterity and gross motor coordination. The test consists of a wooden case and 150 wooden blocks. The participant reaches inside one side of the box, grabs a block, and moves it to the other side of the box to release it. Scores reflect the number of successful task completions in 1 minute. This activity mimics many movements needed to perform everyday tasks, such as grasping, transporting, and releasing objects.[41]

The Berg Balance Scale (BBS) was originally developed to screen elderly people for falls. However, it has become an acceptable tool for assessing functional outcomes and risk for fall in individuals after stroke as well.[42–44] The BBS is composed of 14 items that relate to functional balance tasks encountered daily. Intrarater reliability and content validity have been established for the BBS. Test scoring is on a five-level scale of 0 to 4, with a total score ranging from 0 to 56, and higher scores representing better balance.[45]

The Timed Up & Go test (TUG) was developed to evaluate functional mobility in frail elderly, but validity and reliability have also been established in individuals with stroke.[46,47] In the TUG, individuals are instructed to arise from a chair of standard height and depth, walk at a comfortable speed to the end of a 3-m walkway, turn, and walk back to the chair and sit down.[46,47]

In the 3-m walk test, the time required by each individual to ambulate 3 m was measured using the same walkway as the TUG. Because functional mobility requires ambulation in multiple directions, both forward and backward ambulation was evaluated.

The 6-minute walk test (6MWT) is a performance-based, submaximal test that estimates cardiorespiratory endurance and provides information about functional walking ability. The interclass correlation coefficient for the second and third administration of the 6MWT has been reported to range from 0.96 to 0.99.[48]

Statistical analyses

Paired sample *t* tests were used to compare all pre- and postintervention measures. Pearson correlations were then performed to explore relationships between intervention characteristics (hours and days) and each outcome measure. In addition, to explore the effects of chronicity of stroke, participants were subdivided into one of three groups according to time post CV event: short duration (S, $n = 14$) for individuals who were 24 months or less post CV event; moderate duration (M, $n = 15$) for individuals who were 25 to 60 months post CV event; and long duration (L, $n = 6$) for those individuals who were over 60 months (5 years) post CV event. Mixed-design analysis of variance

Table 3. Mean scores for all outcome measures

Outcome measure	*N*	Pretest (mean±SEM)	Posttest (mean±SEM)	*t*	*p*
3-m forward	29	7.0±1.4 s	5.4±1.1 s	3.3	.003
3-m backward	26	14.1±3.0 s	10.3±2.3 s	3.6	.001
TUG	30	31.0±7.8 s	20.2±3.9 s	2.3	.032
6-min walk	30	228.6±22.3 m	276.5±24.2 m	–8.6	.000
Berg Balance	32	46.5±2.3	47.2±1.9	–3.2	.004
Fugl-Meyer (m)	34	31.8±3.2	37.0±3.3	–7.3	.000
Fugl-Meyer (ROM)	34	21.8±0.5	23.1±0.4	–3.6	.001
Fugl-Meyer (s)	34	8.7±0.6	9.6±0.5	–3.6	.001
Fugl-Meyer (p)	34	22.7±0.4	23.3±0.2	–1.7	.113
mWFMT	29	55.6±7.2	45.2±6.6	3.8	.001
Grip strength	36	13.8±2.0	16.3±2.3	–1.4	.172
Pinch strength	14	3.7±1.0	3.9±1.0	–0.3	.779
Box and Block	11	11.2±3.6	18.0±4.5	–3.4	.007

Note: SEM = standard error; TUG = Timed Up & Go Test; Fugl-Meyer (m) = 66-point Fugl-Meyer motor assessment; Fugl-Meyer (ROM) = 24-point Fugl-Meyer joint range of motion assessment; Fugl-Meyer (s) = 12-point Fugl-Meyer sensory assessment; Fugl- Meyer (p) = 24-point Fugl-Meyer joint pain assessment; mWFMT = mean Wolf Motor Function Test; s = seconds; m = meters; kg = kilograms of force.

(ANOVA), with a pre-post comparison across time, and three groups (chronicity) were used to compare outcomes among the three subsets of patients. Significance was set at $p < .05$ for all tests. Demographic values are reported as mean and standard deviation (*SD*), and outcome variable values are means and standard error (*SE*). All analyses were conducted using SPSS 14.0 (Chicago, IL). For various reasons, including inability to participate in a test or participant unavailability on test day, not all individuals were assessed with each outcome measure. Therefore, the number of participants included in analyses varies among outcome measures. For the outcome measures reported, the number of participants range from 11 to 35, and number of participants is noted with the specific results (**Table 3**).

Results

For the cohort of 35 participants who fit the inclusion criteria, the average amount of therapy received was 72.68 ± 22.53 hours over 16.57 ± 3.85 treatment days (an average of 4.4 ± 0.97 hours per day; **Table 1**). Results of paired sampled *t* tests for all outcome variables are reported later. ANOVA revealed no significant effect of chronicity nor interactions between time and chronicity for any outcome measure ($p > .05$). In addition, Pearson analyses revealed no significant correlations between amount of therapy (total number of hours, total number of days, or average hours/day) and outcomes measured ($p > .05$).

Effects of intensive whole-body therapy on locomotor function and balance

Improvements in locomotor function were observed using the 3-m walk test, TUG, and 6MWT (**Table 3**). The time required to complete the 3-m walk test significantly decreased for both forward and backward walking. In addition, the time required to complete the TUG significantly decreased. Finally, the distance covered during the 6MWT significantly increased.

Significant improvements in balance, as measured through the BBS, were observed post treatment (**Table 3**).

Effects of intensive whole-body therapy on UE function

UE function was assessed using the FMA, 15-item WMFT, the Box and Block Test, grip strength test, and pinch strength test (**Table 3**). Scores on the 66-point motor, the 24-point range of motion, and the 12-point sensory components of the FMA significantly increased between pre- and posttests. Scores on the 24-point pain component of the FMA, however, did not significantly improve.

The mean time to complete the WFMT significantly decreased between pre- and posttests.

These time scores translate into an average of 26.8 ± 4.8% improvement in UE function as measured by the WMFT. In addition, performance on the Box and Block Test significantly improved post intervention. However, neither grip strength nor pinch strength significantly improved.

Discussion

This retrospective data analysis was conducted to evaluate changes in functional outcome measures as a result of intensive, whole-body therapy in patients with chronic stroke. The results presented here demonstrate that an intentionally integrative program such as ours, carried out in a community clinic, is both feasible and effective for a heterogeneous patient population. Our data provide evidence that intensive whole-body therapy can significantly improve locomotor function, balance, and UE function in individuals who are more than 1 year post CV event.

Locomotor function and balance

The improvements in locomotor function observed in the current study appear to be in line with the results of previous studies evaluating the effects of more focused locomotor training paradigms.[30–32,35,49] Specifically, the improvements in the 6MWT distance among our participants were, on average, greater than those obtained in a recent study in which participants who were 4 months to 5 years post CV event participated in 6 weeks of training (4 days per week) that combined specific locomotor training activities with lower extremity strengthening activities.[49] Additionally, our changes were similar to the findings of Macko et al., who conducted a specific treadmill training protocol over a 6-month period (three sessions per week) for individuals who were 6 months or more post CV event.[50] This suggests that there are no apparent drawbacks to using an integrative approach. In fact, participation in more intense, comprehensive therapy over a shorter amount of time may increase functional capabilities sooner.

The locomotor function gains observed in the current study allowed patients to progress from being considered "least limited community ambulators" to "unlimited community ambulators."[36] Schmid et al. described gain to a higher class of gait speed to be associated with substantially better function as well as quality of life.[51] The change from 0.6 to 0.8 m/s in our study (as measured by the 6MWT) demonstrated improved community participation. One patient reported that she was able to begin driving, volunteering, and traveling with her husband again because of her improved mobility.

It should be noted that although our data reveal a statistically significant increase in BBS scores, the change score did not meet the 6-point change score that would constitute a minimum detectable change.[52] This is an interesting finding considering the noted improvements in functional walking distances, suggesting that meaningful improvements in locomotor function are not dependent upon meaningful changes in balance. However, it is important to note that the mean posttest BBS score was 47.2, which is over the cutoff score for an increased risk of falling (45 out of 56). Thus, it is possible that patients who are at a lower risk for falling may not need to improve balance in order to improve functional mobility.

UE function

The improvements in UE function observed across the heterogeneous patient sample included in the current study are consistent with previous research that evaluated the effects of more focused treatment on more homogenous patient samples.[14,15,24,26,29,52] The improvements in UE function indicate that patients with lower functioning hands (defined as less than 25 on FMA motor test; 17 of the patients in the current study) progressed from no hand and arm function to activities such as being able to abduct the arm for improved hygiene and easier dressing, placing the hand on a table to stabilize books and paper, and to hold nonbreakable items with the forearm during transport. One low-functioning participant reported that after treatment he was able to stabilize the door-frame on his car with his involved left hand while he repaired it with his right.

Medium functioning upper extremities (defined as 25–40 on the FMA motor test; 5 of the current patients) progressed to using the hand as a functional assist for activities such as holding a bottle while removing the lid or holding an onion while slicing, using both hands for bilateral activities such as pushing a grocery cart, and using the arm for gross activities such as turning on a light switch. MacClellan et al. included both moderately and severely impaired individuals with CV events in their study on the effectiveness of robotic training on UE function.[24] Their massed-practice design demonstrated that more severely impaired individuals made significant gains in UE function as a result of training. It is critical for physical and occupational therapists to be aware of this potential in more impaired individuals so that such patients get the opportunity to make functional gains. Perhaps achieving even some minimal level of function can serve as the critical point that allows individuals to then progress to more meaningful, higher level changes.

High-functioning upper extremities (defined as more than 41 on the FMA motor test; 12 of the current patients) progressed to unilateral and bilateral functions such as cutting food with a knife and fork, carrying groceries in both hands, picking up items, vacuuming, and using both hands to fold laundry. This evidence provides support for the implementation of task-specific training as only one component of an integrative, whole-body intervention, rather than performing UE massed practice in isolation.[15,24,29,53] One such patient stated that he was able to punch the code into the garage door with his involved hand while holding groceries with the other.

Caveats and Future Considerations

Both statistically and clinically significant gains were documented in this retrospective study, but several issues need to be addressed in future research. First, future studies should incorporate multiple baseline timepoints to assess spontaneous recovery. Even though it is well documented that little spontaneous recovery occurs more than 1 year after a CV event,[54] spontaneous recovery cannot be ruled out as an explanation for the recovery observed in the current study. However, the participants did range in time post CV event from 12 to 123 months, and it is highly unlikely that patients with long-standing strokes would continue to make spontaneous recovery. In addition, we observed no effects of chronicity of stroke on outcome measures, indicating that individuals with long-standing strokes improved similarly to individuals with more recent strokes. This highlights the ability of individuals with long-standing strokes to make treatment-mediated improvements in function and suggests that the gains observed in the current study are a result of treatment.

Second, future studies should use blinded evaluators to eliminate the possibility of evaluator bias. Even though it was not possible to use blinded evaluators in this retrospective study, we do not believe that evaluator bias contributed significantly to the recovery observed.

Third, future research should include a control group receiving conventional forms of rehabilitation (less intensity, longer duration). The current data demonstrate that intensive whole-body therapy promotes recovery of function in chronic stroke survivors, but the lack of correlation between the amount of therapy received and amount of recovery observed leads to the question of how much therapy is required. In addition, the lack of correlation between the average hours of therapy per day and the amount of recovery suggests that individuals receiving 3 hours per day ($n = 8$) benefited similarly to those receiving up to 6 hours per day ($n = 27$).

Fourth, future studies should perform multiple follow-up measures to assess maintenance of gains over time. In the current study, it is not known to what extent functional gains were maintained. However, anecdotal evidence from some of the patients suggests that when they gained sufficient function to use their impaired limbs in the home and community those gains were maintained.

Finally, future studies should include quality of life and patient perception outcome measures in addition to the functional outcome measures presented in the current study. This would provide the opportunity to evaluate all aspects of the International Classification of Function (ICF) model and to increase our understanding of the patient perspective of an intensive, whole-body intervention.

Conclusion

There is mounting evidence for the value of massed practice and/or intensive therapy in the treatment for stroke survivors. However, this approach is not being applied in an integrative manner for the typical stroke survivor in the vast majority of rehabilitation clinics. This retrospective study demonstrates that a treatment paradigm incorporating intensive, repetitious training addressing the whole patient is feasible and can be effective for significant recovery of multiple functions with rehabilitation of chronic CV events in a community clinic.

The improvements in mobility and UE recovery that can be obtained through this treatment approach translate into improvements in patient safety, quality of life, and functional capabilities.

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