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Active-Passive Bilateral Therapy as a Priming Mechanism for Individuals in the Subacute Phase of Post-Stroke Recovery:

A Feasibility Study

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Abstract

Objective—To assess the feasibility of treating inpatient stroke survivors with active-passive bilateral therapy as a motor priming technique before occupational therapy.

Design—Single case series with two matched pairs in the subacute post-stroke rehabilitation phase. The test patients received active-passive bilateral therapy plus upper limb motor training. Control patients received only the motor training.

Results—Both Fugl-Meyer Upper Extremity scores and Action Research Arm Test scores improved in this small group of test and control patients. The magnitude of improvement was greater in test patients who received active-passive bilateral therapy plus unilateral training.

Conclusions—We conclude that it is feasible and safe to administer active-passive bilateral therapy in a hospital setting.

Keywords

Stroke; Upper Limb; Bilateral; Occupational Therapy

Poststroke upper limb hemiparesis is a common condition that physical therapists and occupational therapists address. Although constraint-induced therapy has been found to be effective for patients with mild upper limb hemiparesis,¹ bilateral training is considered a remediation technique for stroke survivors with moderate or severe arm hemiparesis.² Bilateral training may consist of mirror image upper limb movements intended to exploit interlimb coupling dynamics.³ Bilateral priming is a neuromodulatory technique that evolved from bilateral training, which can be used to balance excitability between the cortices before training on unilateral tasks.⁴ The difference between bilateral priming and bilateral training is that, in the latter, bilateral movements are the actual training tasks, whereas in the former, bilateral movements render the motor system more susceptible to subsequent unilateral training.

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Neuromodulation may serve as an adjuvant therapy to improve synaptic efficacy during rehabilitation therapy.⁵ Neuromodulation of motor cortex has been achieved using repetitive transcranial magnetic stimulation,⁶ contralesional paired associative stimulation⁷, and somatosensory input.⁸ A recent study used repetitive movement as a priming mechanism, comparing active-passive bilateral therapy (APBT) plus motor practice with motor practice alone in 32 stroke survivors.⁴ The APBT consisted of repetitive mirror symmetric bilateral wrist flexion-extension that was performed for 10 mins before motor practice. Priming plus motor practice induced larger motor gains than motor practice alone, as assessed by Fugl-Meyer Upper Extremity (FMUE) scores. In contrast to the motor practice only group, the priming plus motor practice group retained their gains at follow-up. Also, priming plus motor practice induced greater normalization of short-interval intracortical inhibition and transcallosal inhibition than motor practice alone.⁴ Motor priming using APBT is noninvasive, and to date, no adverse effects have been reported. This study was funded by the Buchanan Family Fellowship for Occupational Therapy as a feasibility study to identify recruitment and compliance issues and to assess the rate of clinical score change in a small group of individuals admitted to inpatient rehabilitation after a stroke. Here, we describe the first documented use of APBT as a priming mechanism for individuals in the subacute phase of post-stroke recovery.

METHODS

Approval from the Internal Review Board of the university was received before recruitment and data collection. All possible participants and their families received an informed consent to read and sign. If reading was difficult, the research team read and explained the information on the consent form, including possible risks and benefits. Inclusion criteria consisted of unilateral stroke 6 wks before recruitment, an FMUE score⁹ between 8 and 25, absence of severe wrist spasticity (no greater than 3 on the Ashworth scale), and no pain or significant orthopedic problems affecting the wrist.

Nineteen individuals signed consent forms. There were three participants who completed one or two sessions of training and were discharged sooner than expected. There were six screen fails because of the FMUE scores. Two subjects could not be scheduled because of extensive rehabilitation services. One participant with significant medical needs (dialysis) could not be scheduled after the first training session. One participant (assigned to the control condition) refused because of reported pain. Four participants consented but then decided not to be in the study before beginning training. Four volunteers who met the study criteria were recruited. Two were assigned as “test (T)” patients and two as “control (C)” patients. FMUE scores of test participants were approximately matched to FMUE scores of controls.

Two participants (T-1 and C-1) had relatively high baseline FMUE scores compared with other individuals in the subacute phase of stroke. The other pair (T-2 and C-2) had lower baseline scores. Characteristics of the test and control participants can be found in Table 1.

Both test and control participants received 20–30 mins of the same motor practice one or two times per day (as their clinical schedule and individual endurance permitted). If scheduling did not permit two sessions per day, then only one session was completed. Also, if the participant strongly objected to a second session on any particular day, their preferences were respected. Test participants always received a 10-min session of APBT before the motor training. The training was administered 5 days per week for 1–3 wks, depending on the participant’s length of stay. The duration of the motor training session (up to 30 mins) was determined by the therapist on the basis of the participant’s tolerance on any given day. The length of the motor practice sessions for each subject was averaged. The total

numbers of sessions plus the average time per session are presented in Table 2. Both control and test participants also received the usual standard care treatment consisting of daily occupational therapy and physical therapy. Side effects such as wrist, elbow, or shoulder pain were monitored.

APBT was administered to the test patients via a device called the Rocker (Criterion Manufacturing, Auckland, New Zealand) (Fig. 1). Both hands are placed and strapped to two vertically oriented plates, which have a mechanical linkage. The vertical plate holding the less-affected wrist drives the plate holding the affected one through the linkage within the case of the Rocker. Participants were instructed to use the less-affected hand to move in rhythmic wrist flexion and extension in the horizontal plane (where gravity is eliminated). Automatically, the paretic hand is passively moved in a mirror image of the less-affected hand. The Rocker allows 150 degrees of flexion-extension. It has a counter that sums the number of full repetitions completed. That number was recorded for each session.

Motor practice included two categories of activities based on task-oriented neurorehabilitation practice in occupational therapy. Category 1 consisted of exercises or tasks that were designed to improve joint stability, mobility, and strength as well as the transport phase of reaching. Category 2 consisted of activities and exercises that would support grasp and release. For each treatment day, the therapist selected two to four activities from each category. A list of the treatment activities is shown in the Appendix.

Outcome measures included FMUE and Action Research Arm Test scores.¹⁰ For both scales, higher scores indicate less disability. For this feasibility study, all clinical assessments were conducted by an experimenter (M.E.S.) who was not blinded. Participants were evaluated before therapy, at discharge, and 1-mo postdischarge.

RESULTS

Compared with baseline measurements, all participants had a decrease in disability, as evidenced by positive change scores in the FMUE and Action Research Arm Test at both time points (postintervention and follow-up). One participant (C-1) had a decline in FMUE score from postintervention to follow-up. However, the score did not return to baseline level. Change scores for both time points of the FMUE and Action Research Arm Test are presented in Figures 2A, B, respectively.

We experienced difficulties with recruitment and retention in this study because of the preferences of the potential participants who often indicated that they did not want to add activity to an already dense daily schedule. One individual stated “I need some rest and relaxation to get well.” Although families supported research participation, some individuals had difficulty perceiving how it could be helpful. This perception tended to occur in individuals with cognitive impairment. Recruitment and retention also suffered from time limits imposed by the length of stay. By the time some participants were eligible for the study, they were close to their discharge date. Fatigue seemed to be related to the amount of standard therapy delivered before APBT the same day, not to the APBT itself. This was evident, as participants were often in bed and resting before the initiation of the training session.

DISCUSSION

Recovery of upper limb motor function after stroke may be hampered by neuroplastic processes such as reduced intracortical excitation and inhibition and by unbalanced transcallosal inhibition.¹¹ Based on a literature review in PubMed, APBT is the first bilateral motor intervention to target the restoration of balance in these neural mechanisms. APBT

may be more effective for more disabled patients who have greater corticospinal tract degeneration.¹² The extent of corticospinal tract degeneration was not assessed in this study. However, a large increase (20 points) in the FMUE score was found for the more disabled patient T-2. This change score corresponds to a 250% increase in score from baseline to discharge. It is notable that there was a large difference in dosage of training and priming between participants T-1 and T-2 (Table 2). Because T-1 had twice as many priming and training sessions as T-2, we would expect greater improvements on the FMUE in T-1. However, both subjects had similar change scores on the FMUE. It is plausible that the greater rate of improvement in T-2 is caused by APBT's effectiveness in subjects with greater impairment.

Both test and control patients improved from pre- to postintervention. However, the magnitude of improvement (higher change scores) was greater in the experimental patients for both outcome measures. Also, at follow-up, T-1 continued to improve on the FMUE, where C-1 had a slight decline (Fig. 2A). Despite the limited number of patients in our study, and the improvements observed in the control patients, the results are encouraging and suggest that APBT is an effective adjuvant therapy for acute and subacute stroke survivors.

An obvious limitation of this study is the difficulty determining whether the magnitude of improvement is as a result of motor practice or natural neuroplastic mechanisms in the subacute phase of recovery. The improvement of all patients could be attributable to the extra half-hour of motor practice for the arm. However, the data suggest that the magnitude of improvement was greater in the patients who also had APBT. Another important limitation is that the clinical rater was not blinded. These limitations would need to be addressed in a future, larger study.

Issues revealed during the study period need to be addressed to enable APBT to be integrated into a hospital rehabilitation setting. Inpatient hospital rehabilitation settings typically offer 3 hrs of therapy per day. The amount of therapy and adjuvant services at the site in this study is unusual. Rehabilitation hospital settings that do not provide in excess of the 3-hr requirement may facilitate greater participation in research, which requires additional motor training. No adverse effects of APBT occurred or were reported to the Institutional Review Board, and the test subjects did not report any wrist pain. This was not surprising because APBT is not invasive. The only participant who complained of pain before dropping out of the study was a control subject who did not use the Rocker. Because the device is not costly, it can be easily implemented into a standard rehabilitation protocol. If APBT is found to be advantageous for individuals in the subacute phase of stroke, this would be more attractive to third-party payers when compared with costly neurostimulation devices currently being examined.

This pilot study occurred in a freestanding rehabilitation hospital, and a larger study is needed to determine the possible benefits of using APBT coupled with motor practice during inpatient rehabilitation. It is possible that the optimum benefit of APBT may be realized in the subacute phase of recovery. However, APBT has also been examined in the chronic phase of post-stroke recovery as part of a home program monitored by researchers via a daily log.^{4,13} Other rehabilitation studies have examined home-based training through telerehabilitation, and, indeed, several telerehabilitation models providing online upper limb training have been reported to be successful.^{14–22} Given that the Rocker is inexpensive and can be easily installed in a patient's home, future studies could also involve participants who have been discharged from the hospital and use the Rocker as a home program. The home environment may allow for more extensive and daily use of APBT, which could be coupled with self-directed motor practice or online monitored practice through telerehabilitation.

Further studies in both hospital and home settings would allow more varied and precise assessment of this novel movement-based neurorehabilitation protocol.

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APPENDIX: CHECKLIST OF TRAINING ACTIVITIES AFTER ACTIVE-PASSIVE BILATERAL THERAPY

Category I (choose 2 to 4 of the following activities)

- ☐ 1 Work on shoulder elbow in supine (place and hold, active asst, reach to target)
- ☐ 2 Practice elbow extension in sitting with the hand of the affected arm fixed on the mat
- ☐ 3 Work on placing hand from lap to table without shoulder elevation and increasing distance of hand placement
- ☐ 4 Active Assist shoulder and elbow coupling while the arm is supported on table (shoulder flexion, elbow extension). Therapist can provide assistance as needed.
- ☐ 5 Work in sitting/side lying/supine or prone on concentric and eccentric shoulder flexion (begin with place and hold and progress to stop and hold).
- ☐ 6 Throw beanbag toward feet after retrieving it from opposite shoulder
- ☐ 7 Work on moving and coordinating the arm and hand to a target (vary the distance of the target).

Wrist

- ☐ 1 Wrist extension/flexion gravity eliminated
- ☐ 2 Wrist extension gravity assisted
- ☐ 3 Place and hold in wrist extension/flexion
- ☐ 4 Isotonic wrist extension/flexion with graded resistance
- ☐ 5 PNF D1 or D2 pattern with distal focus (active or active-assist)
- ☐ 6 Pushing a ball on surface with wrist and fingers positioned in extension
- ☐ 7 Active/Active Assist radial abduction and adduction of wrist
- ☐ 8 Place and hold from forearm neutral to various degrees of supination/pronation
- ☐ 9 Isotonic supination and pronation with isometric holds at end ranges

Finger Exercises (Weight of fingers can be supported by therapist)

- ☐ 1 Gross finger flexion and extension exercises
- ☐ 2 Individual finger flexion and extension exercises (may include blocking exercises)
- ☐ 3 Isometric holds for finger extension
- ☐ 4 Finger abduction/adduction
- ☐ 5 Exercises for thumb in all planes

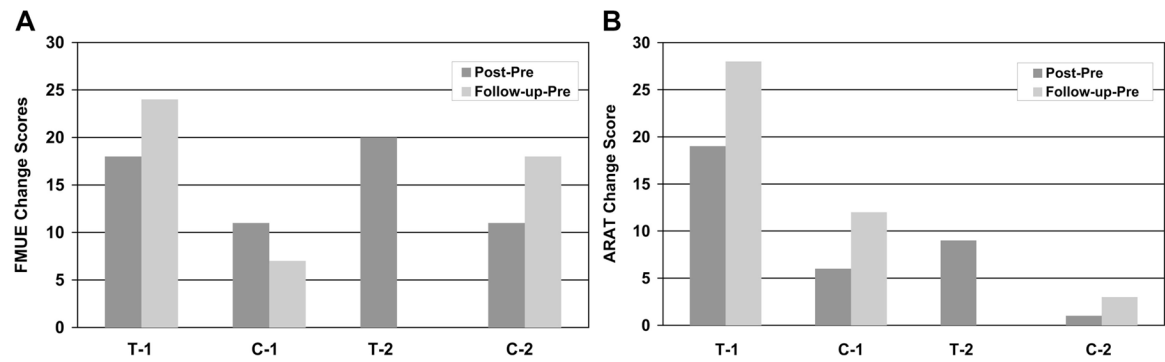
Category II (choose 2 to 4 of the following activities)

- ☐ 1 Strengthen weak grasp by pulling a rolled towel through the hand in radial direction and asking the subject to squeeze and then release
- ☐ 2 Practice holding forearm in neutral position while supported by table

- ☐ 3 Practice holding object that is placed in hand by therapist while arm is supported by table (can use any type of grasp or pinch)
 - ☐ 4 Practice moving the arm with object placed in hand with arm supported on table (with and without vision)
 - ☐ 5 Practice holding an object placed in hand by the therapist while moving the arm in space (not supported by table)
 - ☐ 6 Hold a jar with affected hand and unscrew lid with unaffected one
 - ☐ 7 Strengthen thumb in radial abduction to increase stability
 - ☐ 8 Subject holds object and moves thumb up and down object surface while maintaining grasp
 - ☐ 9 Subject holds small pill bottle in hand and uses thumb to lift lid while maintaining grasp
 - ☐ 10 Grasp object on table that is supported by therapist (therapist is holding/stabilizing the object)
 - ☐ 11 Grasp beanbag on table
 - ☐ 12 Practice holding 1 or 2 lb weight in hand and then lowering it onto mat or floor and releasing
 - ☐ 13 After grasping rolled towel, relax finger flexors. Therapist can position towel in the air so that subject's arm is slightly raised. Use gravity.
 - ☐ 14 Practice holding ball with two hands and then letting go
 - ☐ 15 Pass object from one hand to another
-



FIGURE 1.
A person using the Rocker for active-passive bilateral therapy.

**FIGURE 2.**

A, Fugl-Meyer Upper Extremity single subject change scores (Post *vs.* Pre) and (Follow-up *vs.* Pre) (T, test subject; C, control subject). *B*, Action Research Arm Test single subject change scores (Post *vs.* Pre) and (Follow-up *vs.* Pre) (T, test subject; C, control subject). Follow-up *vs.* Pre data were not available for T-2 because the participant was residing out of state.

TABLE 1

Patient characteristics

Subject	Age, Yrs	Sex	Affected Hemisphere	Time Post-Stroke, Wks	Baseline FMUE	Baseline ARAT	Descriptors
T-1	83	Male	Left	3	23	14	Aphasia, mild apraxia
C-1	65	Female	Right	3	19	11	
T-2	49	Male	Right	5	8	1	Treated with tissue plasminogen activator in emergency room
C-2	76	Female	Right	1	12	3	Mild left neglect

FMUE, Fugl-Meyer Upper Extremity; ARAT, Action Research Arm Test.

TABLE 2

Number and duration of sessions

Subjects	Priming (APBT), Mins	Total Number of Sessions	Motor Training—Average Time Per Session, Mins
T-1	10	14	22
C-1		7	28
T-2	10	7	25
C-2		11	30

APBT, active-passive bilateral therapy.