

Translating Massed Practice Principles to Promote Skill Acquisition in a Patient with Brain Injury

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Abstract

This paper will apply motor learning, massed practice principles, to a patient with a traumatic brain injury from a self-inflicted gunshot wound. Massed practice will be explained and described how it is employed in a clinical practice to promote skill acquisition. Evidence related to the interventions employed with this patient will be described.

Keywords: Motor learning; Massed practice; Brain injury**Introduction**

This paper will describe an actual patient referred to physical therapy (PT) and the translation of skill acquisition to clinical practice. The patient is a 38-year old male, called SWB, with a self-inflicted gunshot wound (GSW) to his head with resultant left (L) hemiplegia. Evidence related to interventions and the implementation of them will be presented.

Patient Description

Very little is known about SWB's medical course other than his injury occurring 6-weeks prior to his initial home health PT visit. SWB was incarcerated and was seen through home health services in a prison setting secondary to shooting his wife and then, self-inflicting his own GSW. It was known that the patient had a long-standing history of drug abuse but otherwise had no premorbid or coexisting medical problems. Pre-morbidly, SWB was employed as a concrete layer.

On inspection, SWB is sitting in a wheelchair with obvious L hemiplegia and right (R) sided facial droop. His R eye is missing, related to the path of the bullet; the eyelid is sutured closed. SWB is wearing a standard sling for his left upper extremity (LUE). He demonstrates facial paralysis on the R side with cranial nerves VII and XII impaired. Subsequently, he has both dysphagia and dysarthria. He is alert, oriented times four (person, place, time, and situation). He is both cooperative and pleasant.

Compensatory strategies are employed by SWB for functional activities. On sit to stand SWB uses primarily his R hemibody and requires moderate assistance. Similarly, in standing he does not bear much weight on his L leg. He ambulates with maximal assistance of one using the wall to provide support. Assistance is provided, by the therapist, to stabilize the L knee during stance phase. A modified forward reach in standing is performed using a manila folder to measure; the patient is not able to reach forward at all, i.e., 0°. This measure is not valid, not reliable, and cannot be compared to the traditional functional reach test [1].

Although independent in transitioning from sit to supine and supine to sit, he employs compensatory strategies using his R extremities to lift his LUE and L lower extremity (LE).

Impairments include spasticity, weakness, inability to isolate movements, and loss of range of motion. SWB's modified Ashworth score is 3, considerable increase in muscle tone, passive movement difficult, for both his LUE and LE [2]. He is able to partially flex his

L hip and extend his L knee with synergistic movement patterns and in the LUE displays a gross flexion synergy. SWB has loss of passive range of motion on his L hemibody with shoulder flexion restricted at 90°, loss of end range finger and wrist flexion and extension, and ankle dorsiflexion 0°. Sensation is impaired to light touch, localization, and sharp/dull discrimination, distal to the L knee and elbow with an accuracy of 75% and 90%, respectively.

Variable Manipulated

SWB has numerous functional losses and impairments. Because of the complexity of this case numerous variables could have been manipulated to address his needs. This paper will address massed practice. Massed practice is defined by Shumway-Cook and Woolacott as a PT session in which the amount of time spent practicing in a trial is greater than the resting time between trials. On the other hand, distributed practice is when the resting amount of time is more than or equal to the amount of trial time. The concept of massed practice differs from conventional therapy [1]. Research by Lang, MacDonald, and Gnip has shown that patients receiving PT after a stroke perform a limited number of exercises and activities during therapy sessions. This is converse to animal research in which the animals perform more than 400 repetitions/day of a task such as reaching [3].

Constraint-induced movement therapy (CIT) is often described in the literature as massed or intensive practice. This method involves restricting functional use of the unaffected arm in patients post stroke while simultaneously intensively training the hemiparetic arm. Conventional PT differs from CIT; the duration and intensity of CIT is much greater than conventional PT. Activities are performed by the hemiparetic arm for many hours/day for consecutive weeks. With CIT this is considered massed practice with the common factor not being the restraint of the unaffected limb, but the concentrated, repetitive, massed practice of the more affected limb [4-10]. Taub, Uswatte, and Pidikiti state, "there is thus nothing talismanic about use of a sling or other constraining device of the less-affected limb" (p.9) [8].

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The principles of CIT for the UE are analogous to the LE. Many articles have begun to research the efficacy of this massed practice to the LE [5,6,10,11]. Marklund and Klässbo employed an orthosis on the uninvolved side of patients with hemiparesis due to stroke to perform intensive practice focusing on balance, weight shifting, strengthening, functional mobility, and walking. Six hours each day were spent in training sessions with the participant performing therapeutic activities 40 minutes out of every hour. In the 5 patients with chronic stroke in Marklund and Klässbo's study, improvement was noted in 77% of the variables measured with a 52% of those variables demonstrating significant improvement [6].

Research by Fritz et al also applied massed practice to the LE. Eight individuals all more than 6-months post stroke participated in an intense mobility program 3 hours/day for 10 consecutive weekdays. The interventions employed an intense LE mass practice schedule where over 20 different activities were done in a 2-hour period that had 2 scheduled breaks totaling 15 minutes. The activities varied greatly and ranged from over ground walking, to sit to stand (STS), to reaching activities in standing, to supine LE exercises. The authors concluded that intense mobility training resulted in significant improvements in mobility and balance [5].

Research by Vearrier and colleagues investigated an intensive massed practice approach in 10 individual's status post stroke. Individuals spent 6 hours in training each day for 2 weeks. The breakdown of those 6 hours include approximately 1 hour dedicated to strengthening, range of motion, stretching, and aerobic conditioning. More than 4 hours were spent each day working on balance, transfers, gait, and education. About one-half hour each day was spent in community ambulation, problem solving, and skills for hobbies, and only one-quarter hour resting. There were significant improvements in anticipatory and steady-state balance control, symmetry in weight bearing, and a reduction in the number of falls. Two subjects experienced improvement in the 3-months following the massed practice. Vearrier and colleagues addressed the constraints of third-party reimbursement and the inability to perform massed practice 6 hours/day outside a research setting [10].

Kwakkel et al. investigated the effect of intensity of rehabilitation after stroke by performing a meta-analysis of 9 studies with 1,051 patients. They found "a small but statistically significant intensity-effect relationship in the rehabilitation of stroke patients... (p.1550)" [11]. The authors defined intensive rehabilitation as receiving approximately 90 minutes of combined PT and occupational therapy a day. It is unclear whether the distributed practice may have been employed and thus, accounting for the small effect. Those receiving intense rehab were compared to those receiving less intense services, i.e., approximately 50 minutes of combined services [11].

In addition to the above articles, Pittman similarly looked at massed practice, 3 hours/day for 2 weeks, in a case report of an elderly male 3.5 years post stroke. Pittman found improvements in balance, mobility, and gait patterns [12].

It is evident that massed practice results in improved clinical outcomes with both the UE and LE. How this happens via cortical reorganization is not explained in the literature for the LE. The research articles presented do not address the 'brain reorganization' with massed practice of the LE.

The basis of CIT stems back to animal research studies. Taub and Uswatte (2003) provide an overview of deafferented monkeys and the downward spiral due to 3 processes in the monkey. Those processes

include: nonuse of the deafferented UE, reinforcement of use of the intact limb, and cortical reorganization, i.e., learned nonuse [9]. Constraining the uninvolved limb in monkeys and forcing use of the involved limb resulted in changes evidenced via neurological imaging. Taub, Uswatte, and Pidikiti discuss the cortical reorganization in monkeys that was evidenced in neuroimaging studies [8].

Subsequently, the forced use and shaping or adaptive task practice concepts transcended from animal research to human studies, and CIT was developed. In humans, CIT was shown to modify brain activity. Through functional magnetic resonance imaging (fMRI) studies and other forms of diagnostic imaging, it was found that activity was occurring in the affected motor and premotor cortexes and the secondary somatosensory cortex. In addition, interconnections from undamaged hemispheric structures could be "engaged." Ipsilesional structures that fired were the cingulate motor area, which drives movement initiation, M1, SMA, and bilateral superior cerebellar hemispheric lesions [13].

When considering diagnostic imaging and how it is done, an UE task can be done while imaging occurs. Performing ambulation, sit to stand, or stair climbing, cannot be executed while neuroimaging is performed. Subsequently, the proof of brain reorganization related to massed practice of the lower extremity cannot be done. It is assumed that brain reorganization occurs in the LE similar to the UE with massed practice.

Implementation

Unlike many patients seen in therapy, SWB did not have other medical issues such as hypertension, cardiac disease, or diabetes. This enabled the clinician to employ a massed practice paradigm and eliminate rest periods. In clinical practice when other patients may be seen concurrently, this one-on-one model may not be feasible. SWB transitioned continuously from 1 activity to another during his PT sessions; this was performed to enable full use of the allotted visit time and employs traditional strength training concepts, in which, performance is observed, when a deterioration in the quality of the exercise is observed, maximum performance has been attained. Rest periods were not provided. When fatigue was noted by worsening performance or an increase in his tone, the task was changed. SWB worked continuously during his 45-minute sessions without a rest.

The implementation of SWB's PT program presented is similar to the activity log presented by Fritz et al. [5] (Table 1). The interventions in Box 1 were not followed in the order presented for every PT session. The order was modified to accommodate the needs of the facility, i.e., whether the patient was permitted on stairs or was treated in his cell because of a lock down. Most PT sessions were held in the common area.

Conclusion

Manipulation of other variables and techniques may have been beneficial for this patient. These include random practice, fading feedback with gradual reliance on intrinsic feedback, mental practice, bimanual training, modified CIT, partial body weight support gait training, and functional electrical stimulation. A review of these variables is beyond the scope of this paper. It should be noted that body weight support gait training, which also employs a massed practice paradigm may have resulted in greater improvements. This is not available in the home health or prison setting.

SWB made significant progress during his 20 PT sessions each lasting 45 minutes in duration. In total, he received approximately

5 mins	Warm up-over-ground ambulation with small based quad cane, stretching dorsiflexors
5 mins	Standing balance tasks, reaching with both hands clasped to address balance, weight bearing on left side, while simultaneously performing self range of motion, weight transfer/shifting, and reaching in standing with feet in varied position, i.e., one foot forward, feet together, feet shoulder width apart, other
5 mins	Repetitive sit to stand without use of arms, emphasizing weight bearing on L LE via flexing L knee greater than R, reaching forward over L LE while performing task
5 mins	Transfers standing to sitting on the floor, via half kneel, alternating legs
5 mins	Positional stretches, balance activities, and weight shifting in quadruped, kneeling, half-kneeling R and L, side sitting R and L
5 mins	Side stepping, backward walking, ambulating while holding or carrying an object with both upper extremities, walking looking over L shoulder and R shoulder, up and down, variable speeds
5 mins	Upper extremity reaching, range of motion activities, and grasp and release, proprioceptive neuromuscular stretching and strengthening activities of the LUE
5 mins	If permitted, ambulation up-down stairs, alternating legs with and without handrail, otherwise overground ambulation with or without assistive device
45 mins	Total treatment time

Table 1: Activity Log-Massed Practice Paradigm for SWB.

16 hours of PT. In the massed practice studies review, subjects received 30 to 60 hours of PT over a 2-week period. SWB received approximately 9 hours of PT in a 2-week period. Progress toward the end of his treatment slowed considerably as the frequency of his visits decreased to 1 visit/week. This was compounded by what appeared to be depression. The requested medical interventions were not received to address his spasticity and depression. In addition, at some point during the 20 visits SWB was denied the opportunity to practice ambulation on the stairs.

Page and colleagues investigated the feasibility of CIT for the UE from a patient and clinician perspective [14]. In 68% of the 208 patients surveyed, patients identified concerns with the time constraints of CIT's practice schedule and the restriction of the unaffected UE. In addition, therapists identified problems with the logistics of safety, compliance, and clinical resources necessary with CIT [14]. Subsequently, a less aggressive approach to providing CIT was developed and investigated by Page and colleagues for the UE [15]. A modified CIT (mCIT) protocol was investigated in which participants had 0.5 hours of PT on 3 days/week and used the more affected limb 5 hours/day, 5 days/week, over a 10-week period. Thirty-five subjects who had chronic stroke showed improvement in arm function with mCIT. The authors concluded the, "magnitude of changes was consistent with those reported in more intense protocols, such as CIT" (p. 333). This reduction in time for CIT, from 6 hours/day to 0.5 hours a day in mCIT may be analogous to LE massed practice research protocols to clinical practice [15].

At the time of discharge from PT, SWB was able to ambulate 10 minutes continuously on level surfaces using a small based quad cane and air cast for his ankle. He was able to ascend and descend 24 steps using a handrail and alternating legs. He was able to reach forward 8" in standing, measured via manila folder. His L UE range of motion remained limited but he was able to perform a gross grasp and release of large objects. If his spasticity could have been medically managed and his services provided on a daily basis or for additional visits, further progress may have been attained. In summary, employing a massed practice paradigm appears to have optimized SWB's PT sessions. Research has show mCIT is effective in making positive changes with a less intense program for the UE. Perhaps future research will show massed practice for the LE of 45 minutes will be effective in improving outcomes similar to the LE massed practice research.

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