

12-1-2014

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Recommended Citation

Takatsuki, Jessica, "PT Management Of A Patient With A CVA Focusing On Functional Training With Neurodevelopmental Treatment-based Interventions In The Inpatient Acute Rehabilitation Setting: A Case Report" (2014). *Case Report Papers*. 3. http://dune.une.edu/pt_studcrpaper/3

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PT Management of a Patient with a CVA Focusing on Functional Training with Neurodevelopmental Treatment-based Interventions in the Inpatient Acute Rehabilitation Setting: a Case Report

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The patient signed an informed consent allowing the use of medical information and photo/video footage for this report, as well as received information on the institution's policies regarding the Health Insurance Portability and Accountability Act.

The author acknowledges G. Noel Squires, PT, DPT, OCS for assistance with case report conceptualization and Amanda Benner, PT, DPT for supervision and assistance with photo and video footage.

ABSTRACT

Background and Purpose: Patients whom have experienced a cerebrovascular accident (CVA) commonly have difficulties with functional mobility. Rehabilitation is a common route taken by individuals who have experienced a CVA in order to regain function and independence. Neurodevelopmental treatment (NDT), a rehabilitation technique, emphasizes the integration of postural control and task performance, control of selective movement for the production of coordinated sequences of movement, and the contribution of sensory inputs to motor control and motor learning. The purpose of this case report is to describe functional training in conjunction with NDT-based interventions for a patient with a CVA during a 3-week stay at an inpatient rehabilitation hospital.

Case Description: The patient was an 80-year-old male who experienced a large right CVA in the setting of atrial fibrillation. The patient received three weeks of daily physical therapy at an inpatient rehabilitation hospital. The examination process revealed many functional limitations and impairments in strength, sensation, balance, posture, motor function and mobility. Procedural interventions had an emphasis on task-specific training and Neurodevelopmental Treatment based interventions, including therapeutic exercise, balance and gait training, and functional training. Progression was documented through outcome measures such as the Berg Balance, Functional Independence Measure and MoCA. Interdisciplinary discharge planning occurred at weekly team meetings.

Outcomes: The patient displayed significant improvements in balance, gait and functional mobility, and level of assistance required. The patient nearly doubled his score on the FIM of 34/126 to 66/126 from admission to discharge, and increased his score on the MOCA from 6/30 to 22/30. The interdisciplinary rehabilitation team recommended temporary placement at a skilled nursing facility in order to continue intensive rehabilitation.

Discussion: Physical therapists within the inpatient rehabilitation environment commonly utilize the importance of functional training into daily therapeutic interventions for patients with a CVA. Dramatic improvements in the patient's functional movement with the use of an NDT approach may warrant using it as a model for patients with similar demographics. Future research exploring the effectiveness of constraint-induced movement therapy, body weight support treadmill training, and traditional therapy versus NDT-based therapy in the rehabilitation of patients with a CVA is warranted.

MANUSCRIPT WORD COUNT: 3,429

Background and Purpose

Cerebral Vascular Accidents (CVAs) are the fourth leading cause of death in Americans, and is recognized as a leading cause of serious physical and cognitive long-term disability in adults. CVAs kill approximately 130,000 Americans each year, which translates to 1 out of every 19 deaths in the United States.¹ 25% of CVAs that occur are in people whom had previous strokes. The two main types of CVAs are ischemic stroke, which accounts for 87%, and hemorrhagic stroke, which makes up the other 13%. Ischemic strokes cause a blockage of the artery that brings oxygen-rich blood to the brain, where as a hemorrhagic stroke occurs when an artery ruptures and leaks blood into the brain.^{1,2}

Rehabilitation is a common route taken by individuals who have survived a stroke in order to regain function and independence, which can take place in either an acute, sub-acute, inpatient, outpatient, or skilled nursing facility. Speech language pathology (SLP) focuses on cognition, memory, attention and speech, while occupational therapy (OT) works to improve activities of daily living. Physical therapy (PT) offers services directed towards increasing mobility, motor function, balance and coordination through exercises and motor learning.² There are many PT treatment techniques that are implemented in inpatient rehabilitation of stroke survivors, including exercises for remediation of impairments, compensatory or alternative methods when deficits cannot be remediated, prescription of assistive and adaptive devices, patient and family education, motor control and motor learning techniques.³

Neurodevelopmental Treatments (NDT) and task-specific training are two concepts that can be utilized. NDT, also known as the Bobath concept, emphasizes the integration of postural control and task performance, control of selective movement for the production of coordinated sequences of movement, and the contribution of sensory inputs to motor control and motor learning. Task-specific interventions are designed to improve postural and movement strategies used by the patient and to restore the neuromuscular functions that underlie motor function.⁴

Although many articles have been published on the PT management of patients with CVAs, there is a lack of insight regarding the effect of specific NDT-based and task-specific training interventions. Thus, the purpose of this case report is to provide clinicians with physical therapy management of patients that present with a CVA using NDT-based intervention strategies and task-specific training in an inpatient rehabilitation setting.

Case Description

CH is an 80-year-old male who experienced a large right sylvian fissure branch Middle Cerebral Artery (MCA) embolic CVA in the setting of atrial fibrillation. Upon admission to the Emergency Department, it was determined he sustained contusions to his left cheek, elbow and hip during his fall, and presented with left hemiparesis, left-sided neglect, dysarthria and dysphagia. The patient was medically managed and stabilized over three days in an acute hospital environment. He was then transferred out to a rehabilitation hospital where he received ongoing medical and rehab services. CH had a CVA three months prior to his current admission, which he made full recovery from and was living independently with his wife.

CH's co-morbidities included chronic atrial fibrillation, hypertension, chronic obstructive pulmonary disease, pulmonary hypertension, congestive heart failure, coronary artery disease, MRSA colonized, depression and hyperlipidemia. CH was on medications for pain, hyperlipidemia, constipation, congestive heart failure, hypertension, as well as medications for prophylaxis of CVA, deep vein thrombosis and hyperkalemia. CH and his family stated their goal was to ultimately allow CH to return home as close to his pre-morbid status as possible. Refer to Table 1 for CH's systems review upon admission.

Table 1. Systems Review upon Admission

Cardiovascular / Pulmonary	
Impaired	Chronic atrial fibrillation, Chronic obstructive pulmonary disease Pulmonary hypertension, congestive heart failure Coronary artery disease
Integumentary	
Impaired	Ecchymosis/swelling on left cheek, elbow, and hip from fall during CVA
Musculoskeletal	
Impaired	Gross strength impairments of the left lower and upper extremity Gross range of motion impairments of the left lower extremity Impaired general mobility
Neuromuscular	
Impaired	Impaired sensation, proprioception and coordination on left lower extremity Impaired sitting balance, transfers and transitions
Communication, Affect, Cognition, and Learning Style	
Impaired	Dysarthria Dysphagia Difficult to assess cognition due to current communication barriers

Clinical Impression 1

Following the subjective history and systems review, it was hypothesized that the patient would present with left hemiparesis, left-sided neglect, impaired range of motion, sensation, proprioception, balance, and mobility secondary to an MCA embolic CVA. At initial hypothesis, it was clear that there were no differential diagnoses upon admission to the inpatient rehabilitation hospital. Additional tests and measures to confirm hypothesis were as follows: Dermatome, myotome & range of motion for bilateral lower extremities, Deep Tendon Reflexes & proprioceptive testing at bilateral Achilles and patellar tendon, Berg Balance Scale, Functional Independence Measures (FIM), Montreal Cognitive Assessment (MoCA) and the Barthel Index (BI). CH was a good candidate for a case report due to limited publication on the interventions that were implemented, including specific NDT-based and task-specific training interventions.

Examination

A standardized PT examination was performed with tests and measures as described by the *Guide*⁵. These included muscle performance, neuromotor development and sensory integration, range of motion, and reflex integrity.⁵ Refer to Table 3 for CH's measures.

CH's strength was tested through use of manual muscle testing (MMT) as described by Kendal.⁶ According to Cuthbert, S.C et al., evidence demonstrates both high interrater-reliability and test-retest reliability for MMT, as well as strong evidence about the validity of using MMT as an examination tool.⁷ CH's range of motion was assessed through manual goniometric measurements as described by Norkin and White.⁸ Nussbaumer, S. et al. evaluated the validity and reliability of manual goniometers, ultimately demonstrating good concurrent validity and test-retest reliability.⁹

A sensory neuromotor test as described by Magee¹⁰ resulted in impaired light touch, deep pressure and proprioception testing. Felix E.R. et al. provides evidence in a peer-reviewed journal article that sensory testing is a valid and reliable adjunct measurement strategy for individuals with neurological dysfunction.¹¹ Although there is no current evidence for the substantial reliability and validity of proprioceptive testing, the face validity of this examination tool is demonstrated in various settings nationwide.

Reflex integrity and muscular tone is commonly impaired following a CVA, though CH presented normal in these categories on initial examination. CH's reflex integrity was measured using reflex hammer, while his muscular tone was assessed using the Modified Ashworth Scale. Tham L. K. et al. demonstrated the validity and reliability of using deep tendon reflexes as an assessment of neurological or neuromuscular disorders through motion analysis.¹² According to Ansari N.N., et al., the Modified Ashworth Scale (MAS) has only moderate reliability and questionable validity of the measurements, although remains the most widely used and accepted clinical scale of spasticity.¹³

The Berg Balance Scale (BBS) is the most commonly used balance assessment for older adults, consisting of 14 items that quantitatively assesses balance and risk of falls through direct observation of their performance. The 14 items are scored on a scale of 0-4, with the lowest score being a 0 and the

highest score a 56. Independent mobility is suggested with a score between 41-56 (low fall risk), walking with assistance between 21-40 (medium fall risk), and wheelchair bound between 0-20 (high fall risk). According to Palmer, E.'s clinical review, the BBS demonstrates high inter-rater and intra-rater reliability, test-retest reliability and sufficient internal validity.¹⁴ CH's static and dynamic balance was assessed on both admission and discharge using the BBS.

The Montreal Cognitive Assessment (MoCA) is a cognitive screening test used to assist in the detection of cognitive impairment, which was performed on CH with his primary SLP during admission and discharge. The cognitive domains of the MoCA include short-term memory recall, visuospatial abilities, executive functions, attention, concentration, working memory, language, and orientation to time and place, with the maximum score achievable being 30 points. A score between 18-26 indicates mild cognitive impairment, 10-17 moderate cognitive impairment, and less than 10 severe cognitive impairment. A study conducted by Tu, Q., et al. revealed good reliability and validity of the MoCA in ischemic cerebrovascular disease patients.¹⁵ Please see Appendix for CH's MoCA at discharge. Refer to Table 2 for CH's measures of impairments at both admission and discharge.

On initial examination, CH scored 0 out of 30 on the BBS, indicating high fall risk, and a 6 out of 30 on the MoCA, indicating severe cognitive impairment. He required maximum manual assistance of two people to prevent imbalance during bed mobility, sitting balance and transfers. Due to CH's extensive impairments, referral and consultation were also made to Speech Language Pathology, Occupational Therapy and Neuropsychology.

Table 2. Measures of Impairments at Admission and Discharge

	Admission	Discharge
Left Strength		
Hip flexion	0/5	2/5
Hip Abduction	0/5	2+/5
Hip Adduction	0/5	3/5
Knee Flexion	2/5	3-/5
Knee Extension	2/5	3-/5
Ankle Dorsiflexion	0/5	1/5
Ankle Plantarflexion	0/5	1/5
Left Range of Motion		
Ankle dorsiflexion	-5 degrees	0 degrees (neutral)
Left Tone/Reflexes		
Modified Ashworth Scale	0/4 (normal)	0/4
Reflexes	2+ (normal)	2+
L Sensation		
Light touch	Absent	Impaired
Deep pressure	Absent	Impaired
L Proprioception		
Great toe	Absent	Impaired
Ankle	Absent	Impaired
L Coordination		
Heel to shin	N/A due to muscular	N/A due to muscular
Toe taps	weakness	weakness

Evaluation

CH's symptoms resulting from his CVA included impaired muscle performance, neuromotor and sensory integration. These led to impairments including proprioception, sensation, cognitive function, attention, range of motion and left-sided neglect, ultimately leading to postural abnormalities and elevated fall risk. CH's muscular weakness led to impairments of motor function; his trunk, left upper and lower extremity presented with hemi-paresis. All of these factors were thought to contribute to his decreased independence in functional mobility. CH's Functional Independence Measure (FIM) score upon admission, 34 out of 126, indicated decreased independence with functional tasks. CH's severely impaired cognition, decreased ability to communicate and impaired functional mobility contributed to his inability to return home, fulfill his roles within his family, and participate in recreational or social activities. CH's functional mobility deficits were secondary to a central nervous system insult, which made him a good candidate for NDT-based interventions.

Diagnosis

Given CH's medical condition and multisystem impairments, the following diagnostic category from the *Guide to Physical Therapist Practice* was selected: "Impaired Motor Function and Sensory Integrity Associated with Non-Progressive Disorders of the CNS- Acquired in Adolescence or Adulthood."⁵ This category was selected due to his extensive neuromuscular and musculoskeletal impairments, and subsequently abnormalities of motor and sensory function.

Prognosis

According to Dashe, John F., the major predictors of outcomes in stroke are the severity of the stroke and the patient's age. Other important factors include pre-morbid functional status, comorbidities, type and setting of acute rehabilitation and family and social support.¹⁶ CH's favorable prognostic factors included being independent in his mobility and Activities of Daily Living (ADL) premorbidly, having a strong support system, and participating in an intensive acute rehabilitation program at an inpatient rehab hospital. His non-favorable prognostic factors included all of his comorbidities previously mentioned, the severity of the MCA CVA and consequent deficits, and his age of 79 years.^{2,}¹³ According to the Guide⁵, CH should demonstrate optimal motor function and sensory integrity and the highest level of functioning over the course of 12 months. 10 to 60 is the expected range of number of PT visits per episode of care required to achieve anticipated goals and expected outcomes; CH completed a total of 15 PT visits. Due to CH's favorable and non-favorable prognostic factors, it is anticipated that he will not achieve his stated goals and outcomes and may require a new episode of care.⁵

Plan of care

CH was referred to occupational therapy, speech language pathology, and a neuropsychologist. Weekly meetings to coordinate with the OT, PT, SLP, rehab certified RN, medical doctor, case manager, and neuropsychologist were conducted in order to enhance interprofessional communication and provide overall better patient care. Further testing included administering the Berg Balance scale and the Barthel Index. The Neurodevelopmental Treatment method of interventions does not constitute an exercise regimen; rather, it is a multidimensional analysis of functional deficits that responds to the neural plasticity of the central nervous system.¹⁷ In hemiplegic patients post-CVA, the interventions aim at integrating both the affected and unaffected sides of the body, including increased stimulation and motivation. NDT-based procedural interventions included balance training, basic activities of daily living, bed mobility training, body weight supported treadmill training, gait training, group therapy, neuromuscular re-education, orthotic training, pain management, patient/family education, therapeutic activities, therapeutic exercise and transfer training. Please see Table 3 for patient goals.

Table 3. Patient short term, long term, and discharge goals

Short term goals	Long term goals	Discharge goals
1. Roll to the right with head of bed flat and moderate assistance	1. Patient will be able to perform a squat pivot transfer with minimum assistance in order to return home safely with family assistance	1. Bed / chair / wheelchair transfer: minimum assistance
2. Supine to sit with maximum assistance, with max verbal and tactile cueing		2. Toilet transfer: minimum assistance
3. Perform a squat pivot transfer with max assist x 1 person, with max verbal and tactile cueing	2. Patient will be supervision level in manual wheelchair 100 feet in order to return home and mobilize household distances safely	3. Ambulation: moderate assistance
4. Wheelchair propulsion with mod assist for 50 feet		4. Wheelchair: supervision

Interventions

Coordination, Communication, and Documentation: In order to enhance interprofessional communication and provide overall better patient care, weekly team meetings were scheduled to coordinate with the case manager, OT, PT, SLP, rehab certified RN, medical doctor and neuropsychologist. Coordination with CH's preferred orthotic vendor was necessary to order an ankle-foot orthosis (AFO). Interventions, outcome measures, and changes in impairments, functional limitations, and disabilities were documented on a daily basis.

Patient and Family Training: CH received daily education in regards to his plan of care, and intervention strategies including bed mobility, postural control, body mechanics, transfer training, sitting and standing balance, weight shifting, wheelchair management, gait training and internal and external feedback. The patient participated in weekly group therapy for support and education on risk factors and the physiology of his current condition. The PT had the opportunity to discuss and explain CH's progress, limitations and discharge plans to his wife on almost a daily basis, since she was present for the majority of his therapy sessions. Education on equipment, such as the AFO and large base quad cane, was also incorporated into these sessions.

Procedural Interventions:

CH was scheduled for PT daily for 1-hour sessions on weekdays during his rehabilitation. CH attended a total of 15 sessions, where the interventions were classified by the *Guide's* categories: therapeutic activities, functional training, and application of equipment.⁵ The focus of CH's interventions was on functional training and neuromuscular education, which included both task-specific and NDT training.

The basic principle of motor learning is to repeatedly practice a particular task in order to relearn. Bayona et al. states that repetitive motor activity alone is not enough to produce representational plasticity, whereas task-specific exercises in combination with motor learning have had the best results in creating functional reorganization of cortical motor maps.¹⁸ Balance, gait and functional training were interventions implemented during CH's therapy that focused on task-specific exercises.

Balance and coordination training were performed over the course of CH's 15 sessions using a progression of activities from static sitting at the edge of bed to static standing in the parallel bars. Progression was quantified by the amount of assistance the patient required and the amount of time the activity was performed. Various sensory training strategies were implemented including use of a mirror for visual feedback, as well as a variety of verbal and tactile cues.

Transfer training was a type of functional training necessary to increase CH's independence in self-care. This intervention was progressed from sequencing of bed mobility, including rolling and supine to sit, to squat pivot transfers. Progression was quantified by the number of people needed for assistance, the amount of assistance necessary and the number of tactile and verbal cues given. Bed mobility and transfer training emphasized NDT by teaching CH specific sequencing of interventions in order to promote independent bilateral movement. These techniques also encouraged natural movement and cognitive awareness for the patient's concentration.

According to Kamath et al., neuromuscular reeducation and visual control were an integral part of therapy due to CH's presentation of "Pusher's Syndrome" secondary to his CVA.¹⁹ Weight bearing strategies with use of a mirror were progressed from sitting to standing position. The mirror allowed CH to have visual control of his upright vertical position, which was undisturbed and served as a feedback mechanism to regaining proper postural control and awareness. Standing weight-bearing activities progressed to weight shifting exercises and pre-gait stepping, quantified by the amount of assistance necessary and amount of time the activities were performed.

CH began gait training with support at a rail and progressed to using a large-based quad cane. This assistive device was prescribed and fitted for the patient's height and weight, as well as the application of a supportive sling for his left arm during gait training. NDT was highly emphasized in gait training by using several ways to modify sensorimotor input to obtain predictable outcomes of CH's motor responses. Dependent on his responses, the therapist modified her pressure, speed, and hand placement during treatment sessions.

Body-weight supported treadmill training (BWSTT) was utilized as part of CH's gait training, which is found through evidence to contribute substantially to the reorganization of neural circuitry necessary to facilitate walking ability. Task specificity is demonstrated in both overground gait training and BWSTT through repeated stepping practice, which augments greater locomotor recovery than other forms of therapy.²⁰ Progression was quantified by distance ambulated, assistive device used, verbal and tactile cues needed, and amount of assistance necessary. As CH was able to demonstrate more independent functional movement during gait training and BWSTT, less handling and facilitation were given by the therapist in order to maximize independence.

Specific tactile cues, hand placement, muscle facilitation techniques and other neuro-facilitory techniques were incorporated into CH's interventions. These task-specific and NDT-based interventions focused on re-training CH's lost motor control by facilitating desired movement patterns.^{17, 20} See Appendix for photos of CH during these interventions.

Outcomes

To maximize reliability of CH's testing, the same Physical Therapist performed both admission and discharge tests and measures. Although CH did not meet any of his long-term or discharge goals, he exceeded his short-term goals. On admission, CH achieved scores of mostly 0 and 1 on the Functional Independence Measure (FIM), totaling a 34/126. This indicates a "low" score, which is shown to be a significant predictor of discharge destination to a Skilled Nursing Facility (SNF).²¹ On discharge, CH achieved a "medium" score of 66/126, demonstrating a substantial improvement from admission. CH was able to ambulate up to 40 feet with a LBQC and moderate assistance, propel a wheelchair 50 feet with supervision, and stand independently for up to 30 seconds. CH's BBS improved from a 0/56 to 6/56, and his MoCA from 6/30 to 22/30. Please refer to Table 2 for outcomes at admission and discharge. See Figure 1 for FIM progression from admission to discharge. See Figure 2 for progression of distance ambulated over the course of the patient's 15 sessions. See Appendix for FIM levels.

Figure 1. Functional Independence Measure at Admission and Discharge

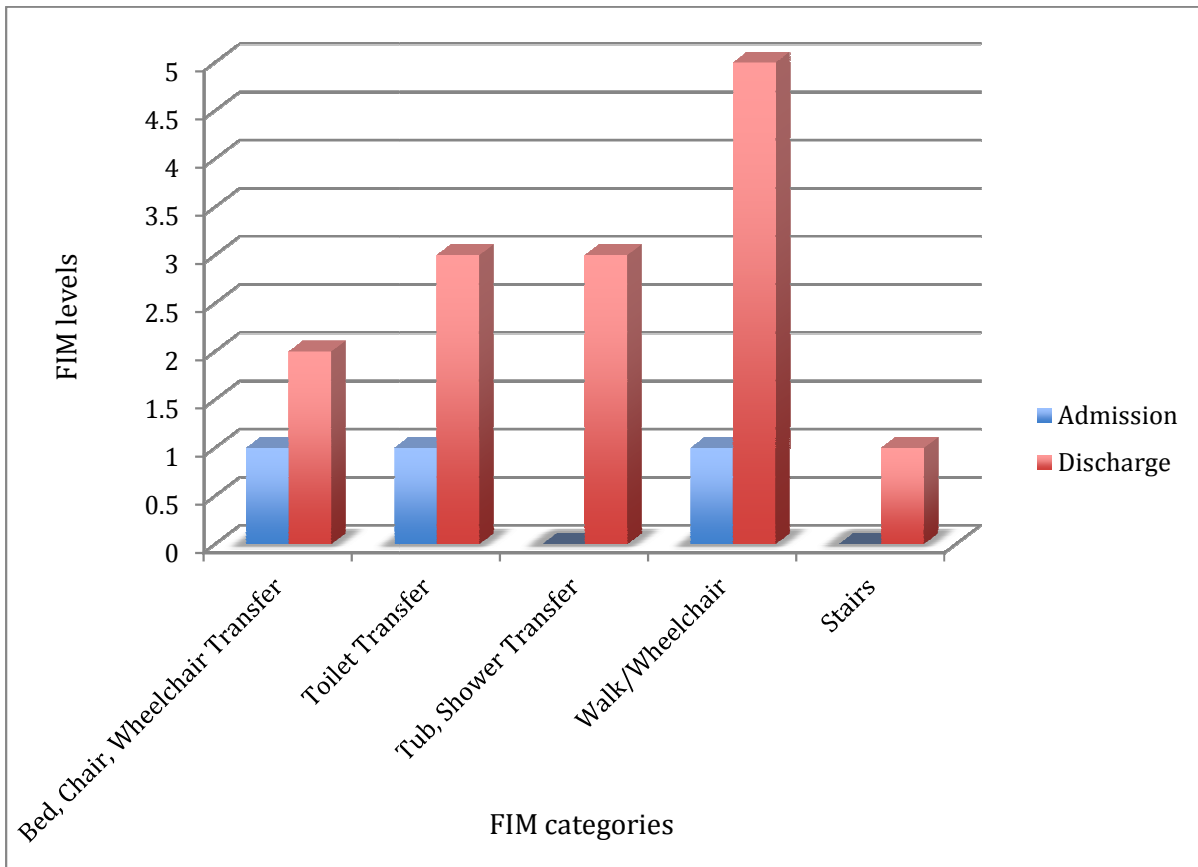


Figure 2. Progression of Distance Ambulated

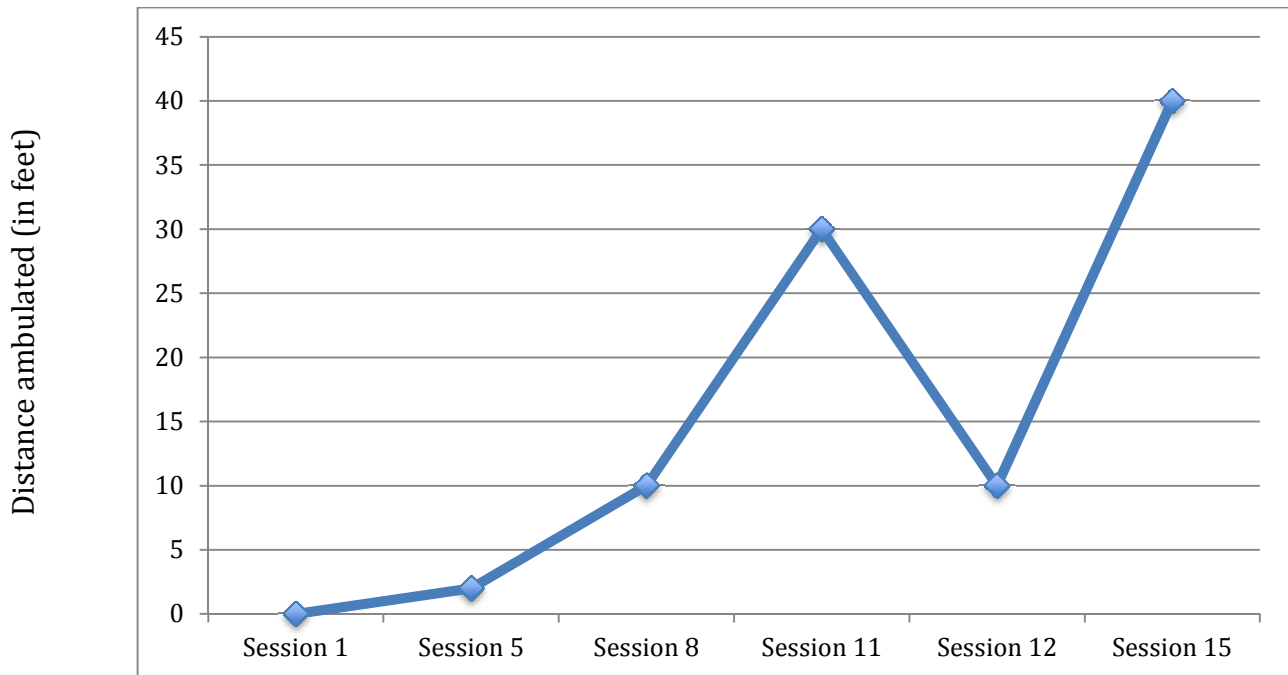


Figure 2. The dramatic decrease in distance ambulated between session 11 and 12 is due to a change from a sturdy wall railing to a Large Base Quad Cane assistive device, therefore a significant decrease in amount of assistance given to the patient.

Discussion

CH made good progress during the 3 weeks of inpatient rehabilitation. The primary focus on functional training exercises was appropriate given that CH had an acute CVA resulting in impairments that severely limited his ability to complete ADL's. CH showed dramatic improvements in his sitting and standing balance, allowing him to complete ADL's with less assistance. His ambulation distance improved and he achieved the ability to maintain standing and walking short distances with a LBQC. Importantly, CH was pleased with the progress that was made. Factors that may have positively influenced CH's outcome include NDT-based bed mobility, transfer training and gait training interventions, patient motivation and consistent emotional support from family.

The scientific literature on CVA provided beneficial information regarding the pathological condition and expected clinical signs and symptoms, providing background information that enhanced the physical therapist's understanding of CH's conditions. This information also provided a basis upon which hypotheses could be formed regarding the underlying causes of the patient's problems, emphasizing the need for a plan of care that maximized CH's functional independence.

It would be useful for further research to be published on patients with CVAs with different approaches to interventions, such as traditional therapy versus NDT-based therapy. Based on best evidence synthesis via various systematic reviews, no evidence is available for the superiority of any therapy approach.²² Many studies reviewed in Kollen et al.'s systematic review include methodological shortcomings. This suggests that further high-quality trials need to be published regarding this topic.²²

Issues that would be helpful to explore include various treatment methods that were not expanded on in this case; for example, body weight support treadmill training on a regular schedule might allow for more substantial improvements in gait distance and assistance than were seen in this case. An exploration of the effect of Constraint-Induced Movement Therapy (CIMT) on increasing motor activity in his left upper extremity is warranted.

Patients with CVAs might benefit from longer rehabilitation stays, allowing for a greater breadth of treatments and progression in their programs, as well as maintaining an intensive therapy schedule. Finally, the breakdown of NDT-based interventions into intervention sequencing and outcomes would be helpful to further explore the effectiveness of NDT-based therapy in rehabilitation of CVAs.

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Session #2
Pusher's Syndrome:
Mod assist with sitting balance



Session #10
AutoAmbulator
Body Weight Supported Treadmill Training



Session #15
Day of discharge; static standing **unsupported!**



Session #15
Day of discharge; Happy CH