THE EFFECTS OF AQUATIC THERAPY, BODY WEIGHT SUPPORT TREADMILL TRAINING, AND HYPERBARIC OXYGEN THERAPY ON GAIT IN A PATIENT WITH CHRONIC STROKES

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ABSTRACT

Introduction: Arteriovenous malformation (AVM) is an abnormal tangle of arteries and veins that as potential to rupture and result in hemorrhagic stroke. Individuals who have experienced multiple strokes are at increased risk for severe disability, musculoskeletal and neurological impairments, and decline in functional status such as decreased gait velocity and endurance. **Case Description:** The patient is a middle aged female with history of chronic strokes secondary to AVM. **Intervention:** The patient was seen once a week for 12 weeks for Body Weight Support Treadmill Training (BWSTT) and once a week for 5 weeks for aquatic therapy sessions. Hyperbaric Oxygen Therapy (HBOT) was attended multiple times a week for 6 months. **Outcomes:** Improvements in gait quality were identified with the Ranchos Los Amigos Observational Gait Analysis (RLAOGA), including increased pelvic stability (decreased Trendelenburg) during stance phase. Gait velocity decreased from .067 m/s to .053 m/s post treatment. Distance during the 6 Minute Walk Test decreased from 27.17 meters to 23.24 meters. **Discussion:** Results may have been negatively affected by psychological stressors such as the patient's father dying of cancer, fear of falling, and decreased independent mobility. Subject reported improved confidence with ambulation. **Conclusion:** A combination of BWSTT, aquatic therapy and HBOT did not improve gait velocity and distance, possibly due to psychological factors; however, pelvic stability increased over 12 weeks. Further research is necessary for longer and specific treatments of BWSTT, aquatic therapy and HBOT with patients having chronic strokes.

Suggested Keywords: Arteriovenous malformation, chronic strokes, body weight support treadmill training, aquatic therapy, hyperbaric oxygen therapy, gait velocity, gait quality, endurance, psychosocial stressors.

Introduction

Brain arteriovenous malformations (AVM) account for approximately 1-2% of all cerebral vascular accidents, also known as a stroke, and are present in approximately 18 out of every 100,000 adults.[1] An AVM is a conglomeration of atypically formed blood vessels, which may potentially rupture and result in hemorrhagic stroke.[2] The exact cause of brain AVMs is unknown, however the research suggests that there a number of possible contributing factors – including genetic components and environmental agents.[1] Brain AVMs may have various long-term effects, such as one-sided weakness, fatigue, balance, cognitive, speech, and vision impairments, and potential for seizures.[2] Further complications may include decline in walking ability, independence with activities of daily living, and involvement in social activities. Previous research reports that many individuals that experience a stroke may experience a gradual decline in overall functional status in the chronic post stroke phase (greater than 6 months since stroke). [3] Additionally, patients that experience more than one stroke have a significant increased risk for severe disability. Further impairments may be noted in muscle strength, coordination, balance, daily ambulation, aerobic capacity, spasticity and lower extremity motor control which can contribute to decreased walking velocity and walking endurance.[4]

Because of the numerous impairments that may arise after a patient experiences a stroke, there must be a multi-factorial approach to treat these patients. Various disciplines work together to provide treatment including physical therapists, occupational therapists, speech language pathologists, physicians, nurses, recreational therapists, vocational therapists and mental health professionals. Another form of therapy that may be beneficial in the treatment of a patient post-stroke is hyperbaric oxygen therapy (HBOT). HBOT is used as a treatment for various diseases and conditions, including patients after stroke. HBOT sessions involve placing the person within an airtight vessel that has greater than normal atmospheric pressure and 100% oxygen for respiration. This increased amount of pressure improves the amount of oxygen available to the lungs, and it dissolves within the blood which will then target damaged cells. By improving the oxygen availability to damaged cells, this treatment may allow the cells to function more normally. [5-7] Although use of HBOT for patients who have had a stroke is controversial, previous research suggests that HBOT may result in increase in cellular function leading to enhanced cerebral metabolism. [6] Additional benefits from HBOT include increasing the number of blood vessels in a damaged tissue area, improvement of white blood cells and fibroblast function, promotion of tissue healing and improvement in tissue quality.[7] These cellular changes may aid in improvements at the body systems level. As a patient experiences improvement and healing within damaged cells, the patient may be able to increase overall functional outcomes. [5]

Individuals that have had a stroke frequently demonstrate long-term impairments in gait. The research by Bohannon[8] illustrated the various impairments that may occur in an individual post-stroke. The research determined that gait velocity in individuals post-stroke was generally less than 50% of typical, and many subjects were unable to ambulate community distances. Typical gait impairments noted included an increase in double stance, decreased cadence and increased time in single limb stance, and decreased step and stride length on the non-affected extremity versus the more involved extremity. Frequently observed impairments on the affected limb during stance phase included decreased hip extension, Trendelenburg, hip retraction, knee hyperextension or excessive knee flexion, toe-heel or flatfoot initial contact, and decreased dorsiflexion of the ankle. Gait deviations during swing phase of the affected limb included decreased hip flexion, circumduction, and foot drop.[8]

Individuals that have had a stroke also typically demonstrate decreased gait velocity and present with asymmetry, impairing their ability to walk. [9] The most commonly reported limitation after a stroke is difficulty with walking, as it affects independence and quality of life. It is thought that gait improves in the initial 3 to 6 months post-stroke and then plateaus; however, some rehabilitation interventions for patients with chronic stroke (> 1 year duration) have exhibited gains in level of independence, gait velocity and distance. Minimal research exists regarding the improvements and long-term changes in gait post-stroke.[10] Rehabilitation interventions that focus on improvement in gait are an essential aspect of the treatment of patients after stroke.

There are a number of strategies that may be used to improve gait in a patient that has experienced a stroke. Body weight support treadmill training (BWSTT) is a physical therapy intervention that is thought to aid in walking ability with individuals post-stroke. This gait training strategy was derived from previous experiments on cats with complete spinal cord transections, which demonstrated that treadmill training generates an automatic locomotor pattern called the central pattern generator. [10] Research indicates the possibility of eliciting the same response in humans with gait deficits (i.e. stroke, spinal cord injuries) in order to improve gait velocity and endurance. The use of BWSTT increases the amount of steps that occur during a treatment session, increasing the amount of task-specific practice completed. Some researchers believe this activity is effective in increasing strength, endurance, walking speed, coordination, balance and posture. [11,12]

Duncan et al.[13] study took 408 participants post stroke and randomly assigned them to 1 of 3 training groups according to the severity of their walking impairment. The first group received BWSTT 2 months post stroke, the second group received the same training 6 months post stroke, and the third group participated in a home exercise program lead by a physical therapist, that occurred 2 months post stroke.[13] After one year of participation, 52% of the individuals demonstrated improved functional walking ability, and all groups showed improvements in walking speed, motor recovery, balance, functional status, and quality of life. Outcomes at one year were not impacted by the timing of the intervention or the extent of the original gait impairment.[13]

Barbeau and Vistintin[14] identified that patients post-stroke with great impairments in gait received the most benefits from BWSTT. Subjects with severe impairments post-stroke demonstrated better walking ability and postural control during gait training with partial un-weighting of their body weight while ambulating on the treadmill. Researchers identified evidence of transfer from treadmill speed to overground walking speed with BWSTT.[15] Although individual studies indicate some positive outcomes in gait for individuals post-stroke, systematic reviews in the literature indicate that there is still not enough evidence from trials in order to determine the effect of BWSTT for walking after stroke, and that more research is needed to clarify the effects of BWSTT.

Aquatic therapy is an alternative or supplemental intervention that may be used to improve muscle strength, balance and coordination. It may also be used to promote flexibility and to decrease tone. While the effects of swimming on performance and physiological function are well known, the training effects of non-swimming exercises are minimally reported in the literature. [16] Research regarding the effectiveness of aquatic neurorehabilitation is not well known.[17] Few studies have demonstrated that several weeks of aquatic therapy was beneficial in improving balance and strength in the hemiparetic leg in individuals that have had previous history of chronic stroke.[18]

Aquatic therapy may be more appropriate than land-based exercise for older individuals with musculoskeletal problems, as exercise in a water medium reduces weight-bearing stresses on joints due to buoyancy.[1] Buoyancy is the upward force that acts on an object submerged in water. This force is equivalent to the weight of the fluid displaced.[19] Buoyancy can be assistive, resistive, or supportive; it assists upward movement towards the surface and resists downward movement. Buoyancy is beneficial during aquatic exercise because it supports an individual's movement in the horizontal plane. The aquatic environment enhances functional skill development for patients with neurological and musculoskeletal deficits because buoyancy provides support and promotes active movement.[19]

Buoyancy and the warmth of the water also promote relaxation and tone reduction. Aquatic exercises that stimulate the vestibular system help to decrease muscle tone, and specific techniques such as Watsu and Bad Ragaz promote further relaxation and tone reduction. The effects of relaxation and tone reduction make stretching and soft tissue mobilization more effective by allowing the patient to gain more mobility. Higher level activities and functional tasks may be incorporated into aquatic exercise secondary to decreased tone and increased mobility. [20]

The Watsu (Water Shiatsu) technique, developed by Harold Dull in the 1980's, is an aquatic therapy technique based on Zen Shiatsu. Watsu incorporates various passive skills that include soft tissue stretching and mobilization, trunk rotation and elongation, as well as promoting overall relaxation. This one on one treatment approach helps improve soft tissue mobility, and provides the greatest benefits in helping to decrease muscle tone and promote overall relaxation. As the therapist stabilizes the patient's body, the patient is passively moved through the water to generate increased stretch on a specific extremity. Repetitive movement of the water around the patient's body allows the patient to transition during stretches.[20]

Bad Ragaz, developed in the 1960's, is an aquatic therapy technique which incorporates proprioceptive neuromuscular facilitation and muscle re-education to increase a patient's strength and flexibility. This one on one treatment approach uses passive movements to help promote relaxation and tone reduction. It also uses active movement patterns that improve trunk and proximal stability. The therapist acts as the center of stability while the patient moves in a specific direction. Flotation devices may be used for this activity to assist the patient's movements.[20]

Noh et al. [18] performed a randomized controlled trial evaluating the effects of an aquatic therapy program aimed at improving balance ability in individuals post-stroke. Twenty-five patients who were ambulatory, with history of chronic stroke, participated in programs using Ai Chi and Halliwick aquatic therapy methods, which focus on balance and weight bearing activities. Thirteen patients participated solely in the aquatic therapy group while 12 patients participated in aquatic therapy and a gym program. After 8 weeks of intensive therapy, results demonstrated that significant improvements were made in balance, weight-shifting on the affected limb, and knee flexor strength.[18]

Thorpe et al. [21] performed a case report study examining the effectiveness of an aquatic progressive resistive exercise program on lower extremity strength, functional mobility, energy expenditure, functional balance, and self-perception in an adult with spastic diplegic cerebral palsy. After a 10 week aquatic therapy program consisting of stretching and lower extremity resistive exercises, the patient demonstrated improvements in strength, balance, ambulation distance, gait velocity, endurance and self-perception. Individuals with cerebral palsy typically demonstrate movement and postural impairments. Treatment approaches focus on alleviating secondary effects on the musculoskeletal system (i.e. spasticity, muscle tightness, muscle weakness), similar to those experienced by patients who have a history of chronic strokes. However, minimal research exists on the efficacy of aquatic-based interventions in individuals with neuromuscular dysfunction.[21]

It is important to note that there are psychological benefits of aquatic therapy, which include decreased fear of movement and depression, and improvements in motivation, self-esteem, self-confidence and increased social interaction.[20]

The purpose of this case report is to determine if a patient with a history of falls secondary to chronic strokes would improve endurance as well as gait velocity and quality of gait with a consistent treatment of BWSTT, aquatic therapy and HBOT. The Institutional Review Board at The Sage Colleges in Troy, NY approved this research.

Case Description

The patient was a 52 year old Caucasian female who had a history of chronic strokes secondary to AVM. The patient exhibited bilateral weakness and right hemiplegia, with greater deficits on the affected side (right upper and lower extremities) and increased tone secondary to a history of chronic left CVA. The patient had 7 brain surgeries for AVM, including radiosurgery, embolization and two craniotomies. The patient’s most recent surgery was October 2008. The patient participated in HBOT treatments from February 20, 2011 to August 20, 2011. The patient attended HBOT treatment 6 times per week in February, March, April and May, and 3-4 times per week in June, July and August.

The patient presented with dysarthria. She was alert and oriented x 3, and did not demonstrate difficulty understanding and communicating with others, which was important for instructions during intervention. The patient weighed 100 lbs and was 5 feet, 2 inches tall with a BMI of 18.3, which was identified as underweight.

This patient was previously part of an initial study (from March 1, 2010 to May 12, 2010) in which the patient was referred to physical therapy for gait training, balance, range of motion, postural control, strengthening, transfer training, bed mobility, safety training, kinesio-taping, electrical stimulation, endurance program and HEP instructions. The patient experienced a few falls and a decline in functional status since this initial study; therefore this current study was a continuation of previous research with primary focus on general strengthening, gait training, and endurance. The patient ambulated with a walker, or used a wheeled walker or power chair. At the time of the patient's initial evaluation, the medications included Keppra and Celexa, and vitamin D. After the initial study in 2010, the patient's Berg Balance Score (BBS)[22] increased from 16/56 (100% risk for falls) to 25/56, and her Activities Balance Confidence (ABC) Scale[23] scores improved from 32.5% to 60.63%, indicating an overall improvement in balance and confidence levels. Although significant improvement was observed over the course of the initial study, the patient's status declined after discharge (May 2010) to the date of the start of the current study (March 2011). This decline in status was attributed to a fall in the home that resulted in hospitalization. The decline was also attributed to decreased independent mobility secondary to fear of falls and decreased strength of bilateral lower extremities which increased her difficulty to perform simple motor tasks.

Examination

At time of initial evaluation, the patient had no complaints and her vitals were within normal limits. She had full active control of left upper and lower extremities and her range of motion was within normal limits. The patient demonstrated decreased right upper and lower extremity range of motion, strength, and coordination.

Manual Muscle Testing[24] indicated 2-/5 for right hip flexion and extension. The patient demonstrated 1/5 for lower extremity abduction, internal and external rotation. She exhibited 2-/5 for right knee flexion, 1/5 for ankle plantarflexion, and 0/5 for ankle dorsiflexion, inversion and eversion. Increased muscle tone was evident in the patient's right upper and lower extremities. The muscle tone was noted in her right upper extremity, specifically in her shoulder, elbow and wrist musculature. Muscle tone was also noted in right lower extremity musculature, specifically in her hip flexors, adductors, internal rotators and knee extensors. Refer to Table 1 for specific muscle tone values as measured by the Modified Ashworth Scale (MAS).[25] The MAS is one of the methods that is used to measure muscle tone, and involves the therapist moving the patient's limb through the range of motion to passively stretch specific muscle groups. Ashworth has shown a five-point scale from 0 to 4 in order to grade the amount of resistance present during passive muscle stretching. On the scale, a score of 0 represents no muscle tone and a score of 4 represents the limb rigid in flexion or extension.[25] Deep tendon reflexes were also measured at the time of evaluation, and values can be found in Table 2.

Goniometry was used to measure range of motion of the extremities.[26] She demonstrated 10° active range of motion (AROM) of shoulder abduction, 0-75° of shoulder flexion passive range of motion (PROM), 0-94° of shoulder abduction PROM, 0-108° of elbow flexion PROM, and elbow extension and wrist flexion were within normal limits (WNL). Her lower extremity PROM for right ankle dorsiflexion was -14°, right ankle AROM plantarflexion was 2°, right hip flexion active AROM was 0-60° and right hip extension AROM was 0-5°. Her left upper and lower extremities were found to be WNL upon the examination. Refer to Table 3 for range of motion and Table 4 for strength values.

The ABC Scale and the BBS were planned as outcome measures to examine the patient's initial balance ability since she was able to perform the tests during the previous research study. However, at the time of the evaluation the patient was unable to perform independent balance testing. The ABC and BBS were therefore unable to be performed due to the floor effect. The ABC Scale[23] is a 16 item self-report measure in which patients rate their balance confidence in performing several ambulatory activities. Items are rated on a scale ranging from 0-100, with 0 representing no confidence and 100 representing complete confidence.[23] The BBS[22] is a 14 item objective measure designed to assess static and dynamic balance and fall risk in adult populations. Various balance tasks are performed and each activity is rated from 0-4, with higher points given if the individual is able to perform the assessed activity. All items are scored with a maximum score of 56, indicating functional balance. Any score < 45 indicates that individuals may be at a greater risk for falls.[22]

The outcomes measures performed in this current study were gait velocity, distance during the 6 Minute Walk Test (6 MWT)[27], and assessment of gait quality using the Ranchos Los Amigos Observational Gait Analysis (RLAOGA)[28]. The RLAOGA is a qualitative, subjective measurement used to help determine differences in quality of gait from onset of the study to patient discharge.[28] The evaluators identify deviations from normal gait at the trunk, pelvis, hip, knee, ankle and toes during frontal, sagittal, and transverse views throughout the entire gait cycle. Gait deviations are categorized as major or minor, but these definitions are not available in general literature. The RLAOGA is one of the most popular and comprehensive scales that covers tri-planar movements at the trunk, hip, knee, and ankle. However, it has poor validity, reliability, sensitivity and specificity when compared to the gold standard− instrumented gait analysis. No values for validity, reliability, sensitivity and specificity can be currently found in the literature.[28] Some of the impairments noted in the quality of the patient's gait included right ankle inversion and foot flat contact at initial contact during the weight acceptance phase, right knee hyperextension and right hip external rotation during the single limb support phase, and limitations in right hip and knee flexion during swing limb advancement phase. The patient also exhibited contralateral pelvic drop, or Trendelenburg gait pattern, during right single limb stance phase, which may be attributed to weak right hip abductor muscles. Additionally, further impairments observed during the patient's gait include decreased ankle dorsiflexion bilaterally and decreased heel strike on the right.

The 6 MWT is another valid, reliable outcome measure found to be related to gait velocity, balance and LE function, and it has been used to measure the efficacy and effectiveness of physical therapy interventions on functional walking ability.[27] The 6MWT is a test used to measure the distance walked in a specified time. This test is considered a measure of endurance rather than speed. In a study performed by Fulk et al.[29] in 2008, the psychometric properties for the 6MWT found included test-retest reliability and minimal detectable change (MDC). The authors state that this test exhibits a high test-retest reliability, with values including the Intraclass Correlation Coefficient (ICC) = 0.973 (95% CI=0.925-0.988) and a MDC(90) of 54.1 m. The authors state that the 6MWT was strongly to moderately correlated with gait velocity (r=0.89), locomotion (walk) FIM (r=0.69), and motor FIM (r=0.52). The authors also note that this test is a reliable test to perform and clinically useful in patients with stroke.[29] Gait velocity is a valid outcome measure that can predict discharge destination and falls, and it is considered a gold standard for measuring walking ability.[27] Additional research has been conducted which indicates that gait velocity is related to lower extremity (LE) strength, LE motor control, balance, functional mobility, gait endurance, energy expenditure and disability in people with stroke.[27] Gait velocity is used to measure the amount of time it takes for a patient to walk a certain distance. Fulk et al.[27] performed a study to determine the psychometric properties for gait velocity. These authors found that in individuals undergoing rehabilitation after stroke, the ICC2,1 was 0.862 and MDC90 was 0.30 m/sec. For patients that needed physical assistance to walk, the values included ICC2,1 = 0.971 and MDC90 = 0.07 m/sec.[29] The initial values for gait velocity and distance ambulated were .067 m/s and 27.17 meters, respectively.

The patient ambulated with a U-Step walker, [30] left heel lift and a right ankle-foot orthosis for functional distances within her home with contact guard to minimal assist of one using a step-to pattern with decreased gait velocity. The patient ambulated functional distances from the living room to bathroom approximately 25 feet. The patient also ambulated anywhere from 100-200 feet during her walking program in the home with an aide or family member for assistance. At the time of evaluation, the patient performed most transfers and bed mobility exercises with moderate assist of one. She was not ascending/descending stairs in the community unless absolutely necessary, in which case she needed moderate-maximal assist of one to perform this task.

The patient's vitals at the time of initial evaluation were all within normal limits. Vitals consisted of respiration rate of 20 breaths per minute, blood pressure of 180/82 mmHg, and a pulse rate of 88 beats per minute.

Evaluation

Several factors influenced outcomes of the research. The patient had a significant amount of hypertonicity that affected her gait, balance, and confidence. Patient identified problems include decreased quality and velocity of gait and decreased endurance, which was the focus of initial examination and treatment sessions. Gait quality and velocity were affected by the following impairments: decreased bilateral lower extremity strength, range of motion and coordination, and increased hypertonicity on the right upper and lower extremities.

Diagnosis

It was determined from the American Physical Therapy Association, Guide to Physical Therapist Practice, that the patient falls under Practice Pattern 5D: Impaired Motor Function and Sensory Integrity Association With NonProgressive Disorders of the Central Nervous System Acquired in Adolescence or Adulthood. The secondary practice pattern is 6B: Impaired Aerobic Capacity/Endurance Associated with Deconditioning.[31]

Prognosis

Due to past medical history of chronic strokes secondary to AVM, it was projected that the patient had a Fair - prognosis over the course of 3 months of BWSTT, aquatic therapy, and HBOT. While it was not expected that the patient would make extreme gains, it was anticipated that the patient would return to prior level of function achieved at the conclusion of the initial study. It was acknowledged that several neurological implications may have limited advancement through treatments.

Plan of Care

The patient was initially seen once a week for BWSTT and once a week for an aquatic therapy stretching and strengthening session. The desired treatment plan at the start included 2 weekly therapy sessions for at least 8 weeks. As the plan of care progressed, the patient was seen for one BWSTT a week for 12 weeks with no specific time constraint. The BWSTT session ended once the patient experienced fatigue. The patient participated in one aquatic therapy treatment session a week for 5 weeks due to scheduling conflicts and pool availability.

The primary focus of aquatic therapy was to temporarily reduce hypertonicity in order to promote stretching, strengthening, balance and gait training. The focus of BWSTT was for gait training. The patient was also encouraged to remain active and motivated in terms of ambulation with walker every day, and to continue her ongoing home program previously established by therapist and home aide. Other components of the plan of care included gait training, strengthening, stretching, body weight support treadmill training, aquatic therapy, and adjuvant HBOT.

The patient's goals at the time of initial visit were to have the ability to walk better, the ability to walk at a more normal pace, and to increase endurance during walking. The physical therapy goals that were established focused on functional improvements including improvement in gait velocity and quality of gait. Physical therapy goals included the following: 1.) The patient will increase her gait velocity from .067 m/s to at least .1 m/s within 12 weeks, 2.) The patient will increase her distance ambulated during the 6MWT from 27.17 m to 40 m within 12 weeks.

Intervention

The intervention period lasted for an overall 12 weeks, with 12 sessions of BWSTT and 5 sessions of aquatic therapy. Time length of BWSTT treatment sessions was determined by the patient, depending on fatigue level and overall energy expenditure. The patient subjectively decided the amount of pounds that she was unweighted at each session. The focus of BWSTT sessions was gait training and increasing walking endurance. The patient wore the BWSTT harness and a curling shoe on her right foot in order to decrease friction and resistance of toe drag on the treadmill. The patient performed a number of walking trials each session and subjectively decided when the trials ended based on tolerance and fatigue. Reasons for cessation of a walking trial included pain in her right foot during the first session, overall feeling of physical fatigue at multiple sessions, and mental/emotional fatigue. At each session, 2 to 3 people provided manual facilitation and verbal cues to help the patient achieve optimal gait quality. Manual contacts were provided to facilitate proper ankle dorsiflexion, knee flexion, and hip flexion/extension at various stages of the gait cycle. Manual cues were also provided at the posterior pelvis as needed to promote weight bearing during single limb stance or to aid in decreasing any extraneous movement of the trunk.

Time of walking trials, speed, blood pressure and the Borg Rating of Perceived Exertion (RPE) [32] were recorded after each trial for the first four treatment sessions, with the addition of heart rate and oxygen saturation monitoring added in later BWSTT sessions. The RPE scale is a numeric rating scale ranging from 6 (no exertion at all) to 20 (maximum exertion). The scale is presented to a subject, who is asked to rate their perceived level of exertion when engaged in physical activity. The RPE scale is a subjective way for a patient to measure their own physical activity intensity level, and may provide a fairly good estimate of the actual heart rate during physical activity. Perceived exertion is how hard an individual thinks they are physically working their body, and may be based on their perception of increased heart rate, respiration rate, increased sweating, and muscle fatigue.[32]

During the initial 4 treatment sessions, some abnormal responses in the patient's vital signs were noted. This included abnormal increases and decreases in the diastolic blood pressure after exercise. However, the patient did not experience any physical symptoms such as dizziness or shortness of breath that would indicate an adverse response to treatment. Furthermore, there could have been equipment error with the blood pressure cuff or stethoscope, or experimenter error as different assessors were taking vitals at different sessions; this may have played a role in the change in values. Follow-up with the patient's primary care physician was carried out in order to assess the patient's overall condition and to obtain written approval for continuation of the BWSTT intervention session. Table 5 depicts each of the average values for the time of walking trial, speed, RPE and other vital signs for the 12 BWSTT sessions.

Each aquatic therapy session lasted for approximately 1 hour and incorporated stretching, strengthening, and pre-gait training exercises. The number of aquatic therapy sessions was low because of pool availability, lack of lifeguard availability and scheduling conflicts. The patient enjoyed being in the pool and reported feeling increased safety in performing pre-gait training exercises. Most sessions were held in a pool that was not wheelchair accessible, so a two-man maximum assist transfer was performed to transfer the patient from her wheelchair to a supine position on a standard lifeguard backboard. One strap was placed over the patient for safety and support, and then a three-man backboard entry was performed to get the patient from the deck to the pool. The pool temperature ranged from 80-85˚ depending on the treatment day, so the patient's core temperature was maintained by wearing a standard wet suit.

At the beginning of each session, the patient was given time to acclimate to the water and perform standard weight shifts and standing marches as a warm-up. The main focus of the aquatic therapy sessions was to incorporate pre-gait training and lower extremity strengthening techniques in a more safe and secure environment. Additional techniques were used at the beginning of each session to promote regulation of muscle tone and to provide lower extremity stretching. Examples of these methods were the Watsu and Bad Ragaz techniques.

The Watsu technique[20] was used for stretching and strengthening of the involved lower extremity. The patient was held facing the therapist in a sidelying position, supported under the neck and holding the bottom (left lower extremity) in hip and knee flexion. The involved lower extremity was moved through flexion and extension by using the water resistance and therapist movement. The patient was then able to move the affected limb with the resistance to promote a deeper stretch or move the limb against the resistance to aid in strengthening.

Various Bad Ragaz[20] techniques were utilized during the aquatic therapy sessions. A life vest was placed around the patient's neck and an aquatic belt was placed under the mid to lower trunk for patient security and support. The focus was on trunk stretching and promoting relaxation. The patient was lying supine on the surface of the water, and the therapist provided manual contacts and support at mid to upper trunk. The patient was then moved passively by the therapist incorporating trunk side bending with hip abduction/adduction in both directions. Resistance from the water was utilized to promote a deeper stretch and to promote strengthening while moving against the water resistance.

Additional exercises and pre-gait training techniques performed by the patient include step ups, step-overs, and step downs, mini-squats, standing marches, forward and backward walking, and sit-to-stand transfers. Many of these exercises promoted single leg stance and weight acceptance on the involved lower extremity to aid in weight bearing during gait.

Outcomes

The outcome measurements that were assessed included gait velocity, gait quality determined by the RLAOGA scale, and the 6MWT. The outcome measures of the BBS and the ABC scale were not used due to the floor effect.

An improvement observed during the RLAOGA was a decrease in contralateral pelvic drop (Trendelenburg) during the single limb support phase of the right lower extremity. During single limb support of normal gait cycle, the trunk is aligned over the stance leg and the hip abductors of the stance limb stabilize the pelvis over the fixed femur. The hip abductors, specifically the gluteus medius, produce most of the forces at the hip and control the pelvis in both the frontal and horizontal planes during stance phase.[33] The pelvis will demonstrate a slight drop on the contralateral limb that is in swing phase.[34] If the hip abductors are weakened on the stance leg, an excessive and uncontrolled pelvic drop, or adduction, will occur on the contralateral side. It is important for individuals to have strong hip abductor musculature to prevent this Trendelenburg gait. Newman[33] reports that hip abductor muscles must be able to support twice the amount of an individual’s body weight in order to stabilize the pelvis during single limb stance.[33] Since the patient demonstrated weak right hip abductor strength upon initial evaluation, it is evident why a Trendelenburg sign would be observed in the RLAOGA. The improvement in this muscle strength over the course of the study (from a 1/5 to 2-/5) supports the reasoning behind the decrease in the patient's Trendelenburg at discharge. Further strengthening and weight bearing activities with aquatic therapy and BWSTT may have continued to improve the patient's strength and therefore, improved her pelvic stability.

At the initial BWSTT session, the patient walked on the treadmill for an average time of 5 minutes and 59 seconds and an average RPE of 14/20, but was only able to perform 2 trials. At discharge, the BWSTT session consisted of the patient walking for an average of 4 minutes and 6 seconds but was able to perform 3 trials with an average RPE of 12/20. Refer to Table 5 for all BWSTT average values. Lastly, during the initial trial of the 6MWT the patient was able to walk a total of 27.17 meters, whereas she walked for a total of 21.95 meters at the time of discharge. However, at the one month follow up trial of the 6MWT, the patient was able to ambulate for a total of 23.241 meters. These values are depicted in Table 6 and Graph 1. The patient had a gait velocity of .067 m/s at the time of the initial evaluation which decreased to a gait velocity of .053 m/s at discharge. All values for gait velocity can be seen in Table 7 and Graph 2.

Discussion

A patient with chronic strokes secondary to an AVM is at an increased risk for severe disability, leading to significant impairments in gait, balance and functional abilities. The initial design of this study was to use the BBS and the ABC Scale as main outcome measures; however, the patient's level of function was too low at initial evaluation that a floor effect occurred. This case study instead focused on various aspects of the patient's gait, including velocity, quality and endurance.

The patient maintained consistent gait characteristics throughout the course of the study with the exception of a prominent Trendelenburg observed during right single leg stance at initial evaluation. This Trendelenburg is attributed to weak hip abductors on the affected side, potentially from decreased weight bearing and limited functional use. The patient's Trendelenburg was less prominent upon patient discharge. This gait deviation was observed during treatment sessions and reviewed through video analysis at initial evaluation and discharge. Improvements in gait quality may be attributed to strength gains from increased weight bearing on the right lower extremity during BWSTT and aquatic therapy. BWSTT encouraged weight bearing during ambulation, while aquatic therapy involved weight shifting activities, steps ups, steps downs, and forward and backward walking. Verbal cueing was provided for gait quality. Tactile cueing at the right iliac crest of the pelvis was provided for joint approximation to increase right single leg stance time, to increase right LE weight bearing during midstance, and to emphasize right hip extension at terminal stance. Cueing was also provided for right LE advancement throughout swing phase, to increase right heel strike at initial contact, and to prevent right knee recurvatum mid to terminal stance. The improvement noted with decreased Trendelenburg supports the idea that a continued walking and strengthening program may potentially assist in correcting gait deviations. This may then help increase gait velocity and distance over time.

Clinically significant improvements were not noted with gait velocity or distance walked. For gait speed, a minimal detectable change (MDC) of 0.175 m/s is estimated to be a clinically important change in walking ability in people undergoing outpatient physical therapy after a stroke.[29] For distance walked, a MDC of 54.1 meters indicates that the distance walked in 90% of stable patients with stroke undergoing rehabilitation will vary by less than 54.1 meters.[27] Neither of these MDCs was met at patient discharge, indicating that results were not statistically significant. The patient still made important gains throughout the course of the study, including subjective report of confidence and comfort during ambulation. It should be noted that setbacks and decline in functional abilities may be attributed to external factors including her father's death and psychological stressors.

The patient's gait velocity increased during the first half of the study, but it was not a statistically significant change. The patient's gait velocity then declined towards the end of the study at time of patient discharge, which was associated with the same time period that the patient's father passed away. The distance ambulated in the 6MWT was minimally increased at one month follow up as determined by the posttest results. This objective measurement indicated some improvement in the patient's overall endurance, which was compromised at the study's onset secondary to deconditioning. Researchers expected that the patient's endurance level would increase over the 12 week study with increased mobility during treatment sessions. It should also be noted that the patient occasionally experienced abnormal vital sign responses to exercise in terms of heart rate and blood pressure values. Vital signs were monitored throughout BWSTT sessions, and the patient was asymptomatic. The patient's physician confirmed that these changes are expected with an individual that is extremely deconditioned and to continue monitoring cardiopulmonary status throughout the study.

It is possible that if this treatment had been extended, or if external barriers had not been encountered, that greater gains may have been made with this patient. Whether or not a patient is capable of making gains in their movement patterns relates to the dynamic action theory approach to motor control. From dynamic action theory stems the concept of attractor states. Shumway-Cook et al.[35] describes attractor states as certain favored movements performed by an individual on a consistent basis in order to complete everyday functional activities.[35] This theory describes that individuals tend to walk at a preferred pace which is most energy efficient. It also states that there are degrees of freedom to change a preferred pattern of movement, called attractor wells. Deeper wells make it more difficult to change the preferred pattern, which implies a stable movement pattern. Shallow wells imply an unstable pattern. Within patient rehabilitation, movement patterns can be described as stable or unstable depending on how difficult it is to change these patterns. Shumway-Cook et al.[35] report that it is more difficult to modify a stable movement pattern that has a deep attractor well, while it may be easier to improve an unstable movement pattern that has a shallow attractor well.[35] This theory relates to this case study, as the patient with a history of chronic strokes signifies the deep attractor well whose stable movement patterns are more difficult to change. Kelso et al.[36] report that just before an individual shifts into a newly developed movement pattern, that individual may experience a time period in which their movements appear to be more variable, or changing from stable to unstable. Additionally, various researchers have noted this same increase in variability of movement just before the transition into the development and attainment of new, more stable patterns of movement.[35, 37-38] This further supplements our research, as the patient did not make gains other than an increase in pelvic stability throughout the entire study. In fact, the patient experienced variation in BWSTT in terms of number of trials and average time spent performing the intervention. Additionally, variation and even some regression occurred with outcome measurements such as gait velocity and distance ambulated in the 6MWT. These variations and regressions may be indicative of the patient being on the cusp of emerging to a new more stable pattern of behavior, as the patient was acquiring new movement skills. Although the patient experienced significant variability, it is important to note that this variability in movement behavior may have been the precursor to change in our patient.[35] If this research was prolonged for a few more months, it is possible that our patient had the potential to change and make future gains.

Mulroy et al.[11] conducted a study in which individuals post-stroke participated in 12 sessions of BWSTT alternated with 12 sessions of LE cycling or progressive resisted strengthening. Increases in hip extension during terminal stance and hip flexion power was noted in the high response group, and changes in hip and ankle biomechanics during terminal stance were associated with increases in gait velocity.[11] This research is related to our study, as a 12 week time period was also used for BWSTT sessions. Although this study used LE cycling or progressive resisted strengthening, it may indicate that some type of strengthening or endurance program combined with BWSTT for 12 weeks may help correct gait deviations and potentially lead to increased gait velocity. More research is necessary to determine if this course of treatment can truly create clinically significant improvements in patients with chronic stroke.

Several factors may have influenced the patient's motivation and participation during the course of this study, potentially affecting the objective results obtained from outcome measurements. The patient's father had been increasingly ill throughout this study, and passed away at the time of patient discharge. This life changing event may have caused the patient both physical and emotional stress, and it may have affected overall performance with the study. Yoo et al.[39] describes various concepts which emerge from family experiences in end of life care. Negative psychological experiences include exhaustion, tiredness, fear, strain, anxiety, guilt, anger, depression and loneliness.[39] Given et al.[40] found that caregivers ages 45-54 reported the highest levels of depressive symptoms, especially those who were adult children of patients and women; feelings of abandonment were also more prevalent in female and adult children caregivers.[40] Depression secondary to the impending death of a family member may have limited the patient's therapy performance, as emotional experiences can negatively affect physiological function. This includes sleep disturbance, fatigue, loss of appetite and general state of poor health.[39]All of these factors should be taken into consideration when assessing outcome measures and results in this study.

A major contrast from the previous study was the difference in functional status of the patient at study onset. The patient was at a higher functioning level at the start of the previous study in comparison to the onset of the current study. She had a greater level of endurance, functional ability, balance, and confidence. Since she was already starting at a higher function, she may have been able to make greater gains and therefore show significant improvements in the outcome measures used. It is extremely important to note that the patient's functional status and ability to perform activities of daily living (walking, transfers, etc.) were compromised after the conclusion of the initial study, secondary to a fall. Since the fall, the patient self-reported a further decline in status secondary to deconditioning and fear of falling. Krakauer[41] reports that the greater amount of practice performed by an individual, the greater the performance improvement and motor learning that will be able to occur. Due to possible feelings of fear-avoidance after the previous study, the patient may have experienced reduced activity level and limited independent mobility secondary to fear of falling. No practice was performed and as a result, performance improvement did not occur, which Krakauer states is necessary for motor learning.[41] The patient consequentially presented at a lower functioning status at onset of this study than at the onset of the initial study. This lower functioning status prevented the researchers from administering the BBS and ABC scale, as her safety was compromised by her inability to perform specific tasks included in these outcome measurements. Once a patient is below a certain level of function, it is not always appropriate to use certain outcome measurements as a floor effect may be present. This compromises the patient's safety and results may not be reflective of what the patient is capable of doing; it may only relay information regarding what the patient is incapable of doing. Krakauer states that it may be difficult to make improvements in a patient that is starting from a low baseline level, as opposed to starting at a higher level of function.[41] Therefore, once a patient experiences a floor effect, it is important to recognize that it may be more difficult for the patient to regain prior level of function and to make great therapeutic gains.[41]

Another potential barrier to progress may have been the fact that the patient was walking less often and for shorter distances during daily activities prior to the start of this study. Because of the issue of safety and the desire to decrease her risk for falls, the patient had ceased independent ambulation within her home. Therefore, she could only gain the benefits of walking and weight bearing activities when another person was present. This requires increased time commitment from family members or the hiring of an aide to come into the home in order to provide a safer environment for ambulation. This further placed the patient at risk for secondary complications such as decreased aerobic capacity, strength, muscular endurance, increased risk of contractures, skin breakdown and muscle atrophy. The patient also experienced fear-avoidance behaviors, as she reported increased fear of falling, which potentially caused activity limitations and decrease in overall mobility. These two components of safety and fear could have played a significant role in the patient's ability to ambulate confidently prior to the study.

Minimal research exists on functional recovery in individuals with chronic stroke, and the research that has been conducted is varied and inconclusive. Literature indicates that the potential for motor recovery and functional improvements occurs within a 3 to 6 month window for greatest rehabilitative gains[33, 42-44]. Page et al.[42] discuss additional literature that incorporates stroke motor rehabilitation. This literature has shown that after a certain amount of time has elapsed, it will be more difficult for the patient to make improvements and recover function.[42] Similarly, Stinear et al.[45] state that potential for functional gains in patients with chronic stroke depends on corticospinal tract integrity, and these improvements are still possible 3 years post-stroke, although the capacity for improvement declines over time. The Copenhagen Stroke Study, a national study documenting stroke incidence and outcomes from thousands of patients, reports data suggesting that motor recovery should not be expected more than 5 months after cerebral injury. Data from additional studies supports this information, stating that motor recovery should not be expected to occur after more than 6 to 12 months after injury.[42] Furthermore, researchers in the Copenhagen study found that the length of recovery was correlated to the severity of the initial stroke. Greatest ADL function was reached within 8.5 weeks in patients with mild strokes, within 13 weeks in patients with moderate strokes, within 17 weeks in patients with severe strokes, and in within 20 weeks in patients with very severe strokes. This research also states that no significant improvements occurred after this time period.[46] The Copenhagen study reports that the majority of motor recovery occurs within the first 6 weeks after stroke. Additionally, Macko et al.[47] note that 95% of patients with stroke do not demonstrate further improvement in ambulatory ability beyond 11 weeks with conventional care. In both the 2010 study and the current study, the time frame post stroke exceeds the amount of time in which improvements are expected, according to the Copenhagen study. Because our subject was approximately 3 years post-stroke during the time frame of our study, the potential for functional gains may have been significantly decreased at that time. Conversely, Ferrarello et al.[48] state that as many as 40 to 60% of patients will recover functional independence with ADL's and mobility from 3 months to 10 years post-stroke. Ferrarello et al.[48] found that functional gains can be made in the chronic stroke population, although improvements were minimal and not clinically significant. This research is important as it challenges the concept of a plateau. Page et al.[42] believe that patients post-stroke often adapt to physical therapy interventions, and that this neuromuscular adaptation is often mistaken as a decreased potential for motor improvement. Functional and cortical changes can occur in patients with chronic strokes as long as positive adaptations occur in the intervention, such as modifying the exercise intensity, session duration, and varying the intervention itself. [42]

An additional barrier that may have potentially influenced the patient's ability to improve during this study was the possibility of any unknown physiological changes that may have been taking place within her brain, secondary to undergoing 7 brain surgeries. The patient has been through several different types of brain surgery, including radiation surgery during the 1990s, that most likely have caused long term damaging effects on the brain tissue. Furthermore, the patient underwent her most recent brain surgery in October 2008. There could be physiological changes and effects still taking place at a cellular level that would influence her functional abilities.

There were a number of strengths noted throughout this study. A major strength was that a combination of three different methodologies including BWSTT, aquatic therapy, and hyperbaric oxygen therapy was used to promote optimization of function. Another strength includes the fact that this study was based on a continuation of a previous research study that had demonstrated significant improvements in the patient's balance and confidence. The addition of hyperbaric oxygen therapy was an additional strength as it introduced a new area of research to the study. There is minimal research available on the effects of HBOT with physical therapy, therefore our study was designed to investigate the potential relationship between the two interventions.

There were several situational factors that developed over the course of this study that may have affected this patient's outcomes. The first issue included inconsistent lifeguard coverage at the pool, which limited the number of aquatic therapy sessions performed to only 5 sessions. Aquatic therapy treatment sessions were conducted for the first half of the study, which was when most gains were made. Once aquatic therapy was finished, the patient was only receiving half the amount of therapy that was initially received. Additionally, HBOT was initially received 6 times a week in March, April and May, whereas it was only received 3 to 4 times a week in June. Decreased HBOT treatments may have some effect on the patient's outcome, whether it was the patient's perception of HBOT on healing and functional status or the true physiological healing of this treatment. Because the patient took the time to educate herself on the potential benefits of HBOT, she may have truly believed in the positive effects that it was having on her functional status. Once the HBOT sessions ended, the patient may have began to perceive less improvements in her gait, balance, and overall ability secondary to placebo effect.

The duration of the previous and current study was different, which may have impacted the patient's overall motivation and improvements from baseline. The previous study was 73 days, whereas the current study lasted for 83 days. Although the previous sudy made gains over a shorter time frame, the patient had consistent BWSTT and aquatic therapy throughout. Conversely, the current study was unable to provide consistent aquatic therapy treatment, and the amount of sessions was reduced in comparison to the initial study. The patient reported on several occasions that she enjoyed aquatic therapy, was motivated to participate and that she felt she was able to "do more" in the pool. The decreased amount of aquatic therapy sessions may have partially contributed to the minimal amount of improvement observed in this study, as the patient perceived aquatic therapy as therapeutically beneficial.

Conclusion

For this patient, a combination of BWSTT, aquatic therapy and HBOT did not significantly alter gait velocity and distance during a 12 week period. However, pelvic stability increased during ambulation, as seen by decreased Trendelenburg. Gait velocity and distance decreased likely to psychosocial stressors, inconsistent aquatic therapy, and decreased frequency of hyperbaric oxygen therapy sessions. The improvements observed in pelvic stability during gait may be an indicator that a strengthening and gait training program such as this may prove to be somewhat beneficial in a patient with chronic strokes. The lack of significant improvement may be attributed to patient psychosocial stressors and discontinuation of aquatic therapy treatment sessions. Further research including a combination of BWSTT, aquatic therapy and HBOT may be beneficial in patients with chronic strokes. Specific recommendations include emphasis on increased intensity and repetition of all interventions. This may serve to improve clinician's knowledge base and understanding of effective treatment of patients with chronic stroke.

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Table 1. Muscle tone of Right Upper and Lower Extremities at Initial and Discharge

Right UE	Initial	Discharge	Right LE	Initial	Discharge
Shoulder Flexors	1+	0	Hip Flexors	1+	0
Extensors	2	2	Extensors	0	2
Abductors	0	0	Abductors	0	0
Adductors	1+	2	Adductors	1	1+
Internal Rotators	2	2	Internal Rotators	1	0
External Rotators	0	0	External Rotators	0	1+
Elbow Flexors	0	0	Knee Flexors	0	0
Extensors	2	2	Extensors	2	2
Wrist Flexors	1+	2	Ankle Dorsiflexors	0	0
Extensors	0	0	Plantarflexors	n/a	3

Table 2. Deep Tendon Reflexes of Upper and Lower Extremities at Initial Evaluation

	Right	Left
Biceps	0	2+
Triceps	0	2+
Brachioradialis	0	2+
Patellar	3+	2+
Achilles	0	0

Table 3. Active and Passive Range of Motion of Upper and Lower Extremities

Extremities	PASSIVE		ACTIVE	
	Right (initial)	Right (Discharge)	Right (initial)	Right (discharge)
Shoulder Flexion	0-75	0-80	0	**
Extension	WFL	WFL	0	**
Abduction	0-94	0-75	0-10	0-20
Internal Rotation	n/t	WFL	0	**
External Rotation	n/t	0-8	0	**
Elbow Flexion	0-108	0-115	0-2	**
Extension	WFL	0	0	**
Wrist Flexion	WFL	WFL	0	**
Extension	0	0-20	0	**
Hip Flexion (sidelying)	WFL	0-97	0-60	**
Extension	0-12	0-32	0-5	**
Abduction Adduction	0-14 0-5	0-20 0-20	0-8 n/t	**
Internal Rotation	WFL	0-45	0	**
External Rotation	WFL	0-40	0-15	**
Knee Flexion (sidelying)	WFL	WFL	0-46	**
Extension	WFL	0	WFL	**
Ankle Dorsiflexion	-14	-25 (knee straight)	-14	**
Plantarflexion	WFL	WFL	0-2	**

Inversion	WFL	WFL	0	**
Eversion	0-19	0	0	**

*Left LE all motions within functional limits (WFL)

**Active movement of the right upper and lower extremity could not be properly assessed because of the muscle tone and muscle synergy patterns noted during movement.

Table 4. Strength Measurements of Right and Left Upper and Lower Extremities

Extremities	Right (initial)	Right (discharge)	Left (initial)	Left (discharge)
Shoulder Flexion	0/5	0/5	3+/5	3/5
Extension	0/5	0/5	3+/5	3+/5
Abduction	1/5	2-/5	3+/5	3/5
Internal Rotation	0/5	0/5	3+/5	4/5
External Rotation	0/5	0/5	3+/5	3+/5
Elbow Flexion	1/5	0/5	4-/5	4/5
Extension	1/5	0/5	4-/5	3+/5
Wrist Flexion	0/5	0/5	4-/5	4+/5
Extension	0/5	0/5	4-/5	4/5
Grasp	n/a	n/a	4+/5	4+/5
Hip Flexion	2-/5	1/5	3+/5	3/5
Extension	2-/5	n/t	3+/5	3-/5
Abduction	1/5	2-/5	3+/5	3/5
Internal Rotation	1/5	n/a	3/5	n/t
External Rotation	1/5	n/a	3/5	n/t
Knee Flexion	2-/5	2/5	3/5	3/5
Extension	3-/5	3-/5	4-/5	3/5

Ankle Dorsiflexion	0/5	0/5	2/5	1/5
Plantarflexion	1/5	0/5	3/5	3-/5
Inversion	0/5	0/5	2/5	n/t
Eversion	0/5	0/5	2/5	n/t

Table 5. Body Weight Support Treadmill Training Sessions

Treatment session #	# of Trials	Average time (min)	Average RPM (mph)	Average BP (mmHg)	Average RPE	Average HR (bpm)	Average SaO2
1	2	5:59	1.15	WNL	14/20	N/A	N/A
2	6	3:02	1.28	111/77	11.2/20	N/A	N/A
3	4	2:55	1.24	112/76	13/20	N/A	N/A
4	2	4:29	1.32	111/83	12/20	N/A	N/A
5	3	4:17	1.23	109/81	10.3/20	97	N/A
6	4	4:09	1.23	114/72	9.5/20	105	96.5
7	3	2:56	1.29	105/67	12/20	93	96
8	3	5:24	1.33	114/80	11/20	89	97
9	4	3:23	1.39	116/80	11/20	85	97
10	4	5:00	1.41	119/80	10/20	87	97
11	4	4:44	1.45	117/80	11/20	86	98
12	3	4:06	1.50	119/85	12/20	97	98

Table 6. Total Distance walked in 6 Minute Walk Test

Date	Distance (meters)	Distance (feet)	RPE
Month 1	27.17	89.14	10
Month 2	21.95	72.00	11
One month follow up	23.241	76.25	10

Table 7. Changes in Gait Velocity

Date	Speed (m/s)
4/2011	.067
5/2011	.082
6/2011	.053

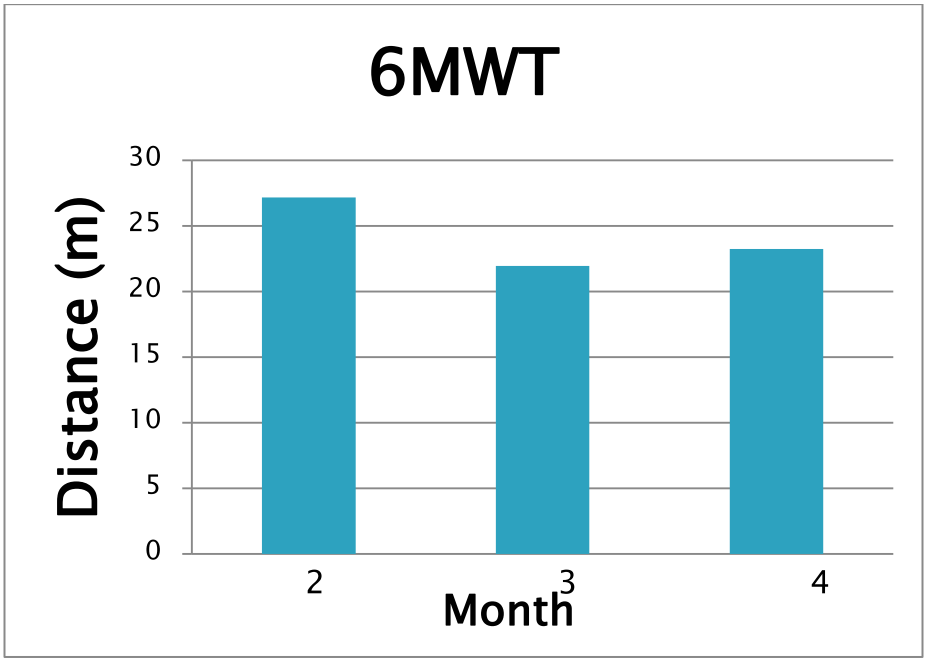

Figure 1. Six Minute Walk Test Results

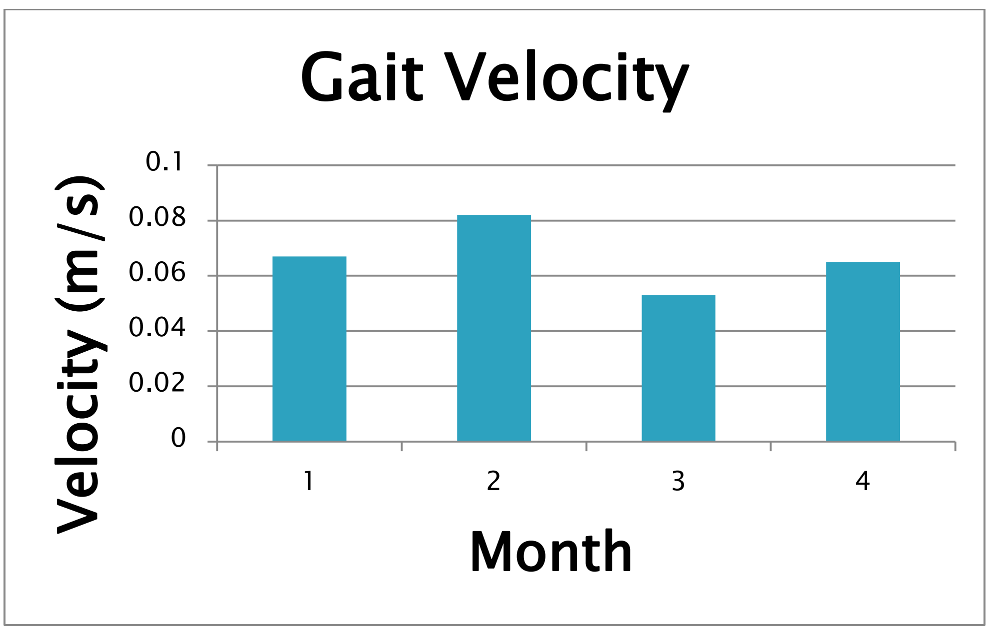

Figure 2. Gait Velocity Results

Figure 3. Body Weight Support Treadmill Training

The patient is unweighted in the harness while walking on the treadmill, as the two therapists provided manual cues for lower extremity advancement and to promote pelvic stabilization.

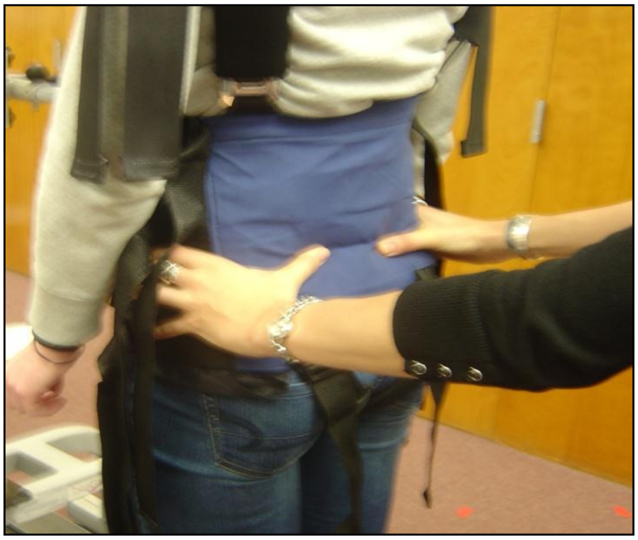

Figure 4. Body Weight Support Treadmill Training Manual Cues

One therapist provided manual cues at bilateral iliac crests to promote pelvic stabilization and prevent excessive pelvic rotation during the intervention.

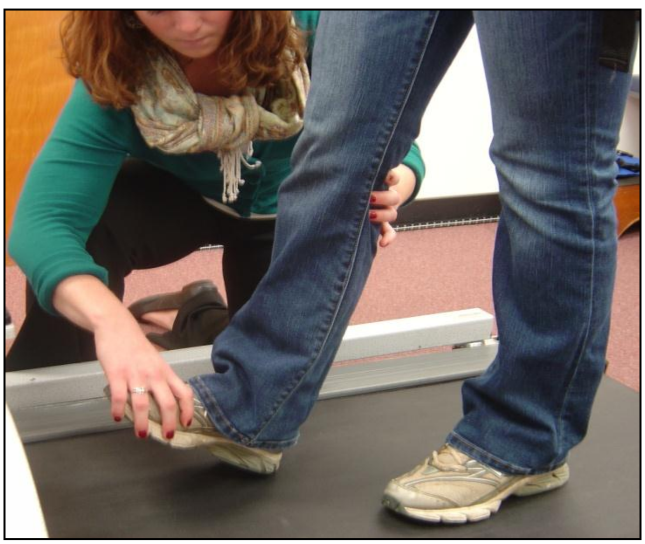

Figure 5. Body Weight Support Treadmill Training Manual Cues
The second therapist provided manual cues at the right lower extremity to advance the limb in swing phase, to prevent toe drag, and to prevent genu recurvatum.

Figure 6. Bad Ragaz Technqiue

The Bad Ragaz technique incorporates proprioceptive neuromuscular facilitation and muscle re-education to increase the patient's strength and flexibility. The therapist acts as the center of stability, moving the patient side to side as the patient is instructed to resist the currents of the water. The water assists the patient with movement, and it helps to improve trunk and proximal stability.

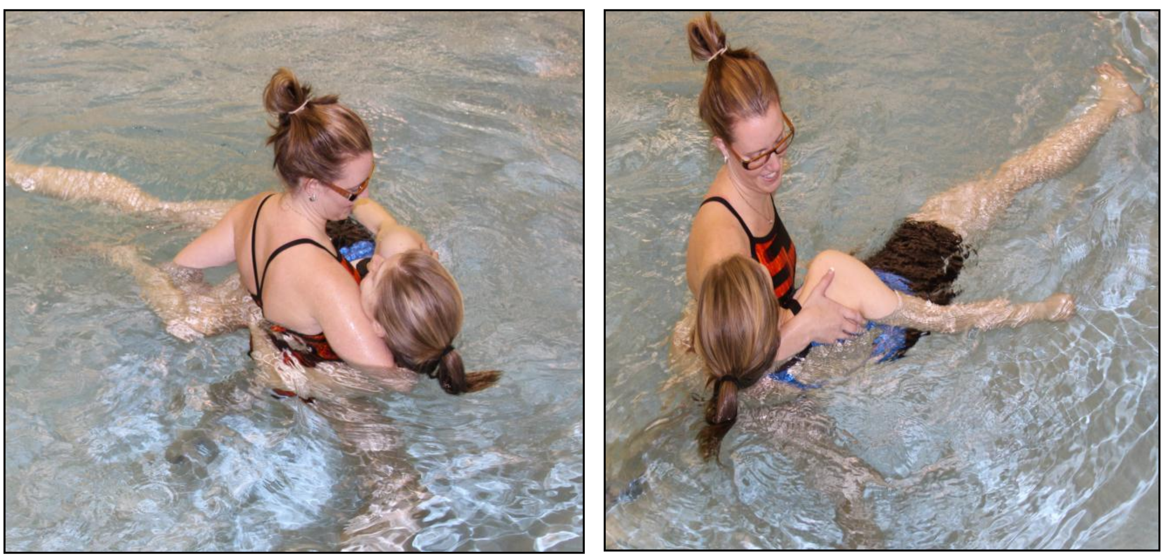

Figure 7. Watsu Technique
Watsu is a passive technique used to improve soft tissue mobility and to promote stretching, relaxation, and tone reduction. The therapist stabilizes the patient's body and the patient is passively moved through the water to generate increased stretch on a specific extremity.

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March 24, 2011

Dr. Laura Gras
The Sage Colleges
Physical Therapy Department
65 1st Street
Troy, NY 12180

IRB PROPOSAL # 10-11-061
Reviewer: Susan C. Cloninger, Chair

Dear Dr. Gras:

The Institutional Review Board has reviewed your application and has approved your project entitled "The Effects of Aquatic Therapy and Body weight Support Treadmill Training on Balance in a Patient with Hemiplega Good luck with your research.

When you have completed collecting your data you will need to submit to the IRB Committee a final report indicating any problems you may have encountered regarding the treatment of human subjects

Please refer to your IRB Proposal number whenever corresponding with us whether by mail or in person.

Please let me know if you have any questions.

Sincerely,

Susan C. Cloninger

Susan C. Cloninger, PhD
Chair, IRB

SCC/nan

Cc. Kailey Egbert
Katharine Leathem
Carin Darbyshire