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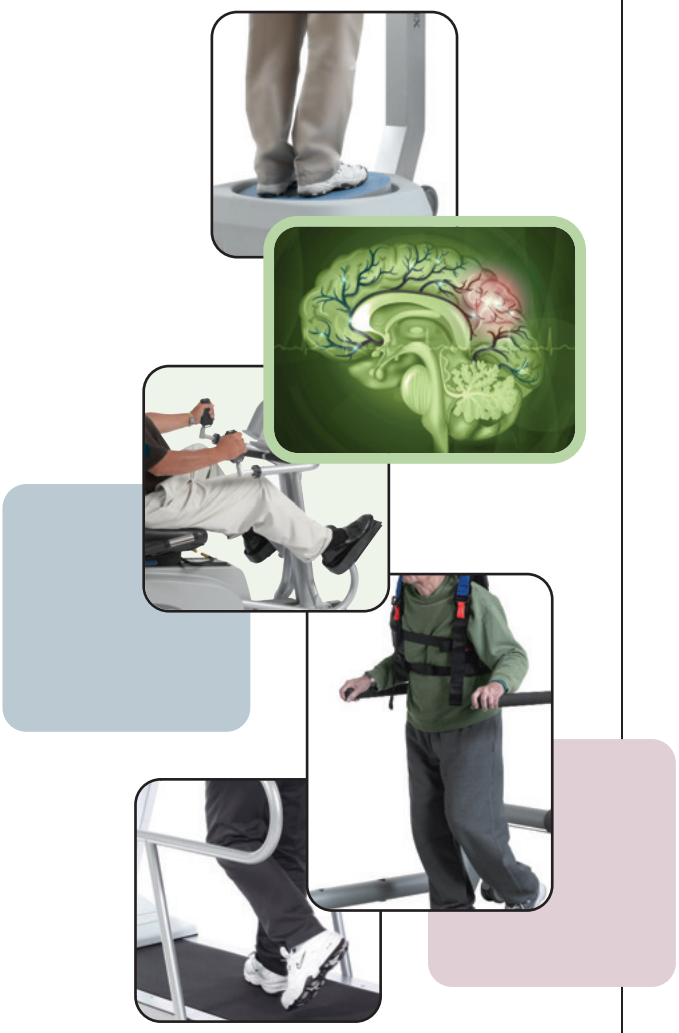

Cerebral Vascular Accident

A Clinical Guideline Using Biodex Technology for the Treatment of Patients Affected by Cerebral Vascular Accident

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Natalie Thompson is a 1992 graduate of SUNY at Stony Brook with a dual degree in Biology and Physical Therapy. She has a background in clinical, managerial and educational settings. Natalie has practiced for more than ten years in orthopedics with specialized training from the McKenzie Institute and Institute of Physical Art. Since 2001, she has focused on working with neurologically impaired patients. Natalie was a hands on manager for United Cerebral Palsy for six years, after which she began treating young children up to five years of age. She was an adjunct teaching assistant for Stony Brook University in the Physical Therapy program. Currently, Natalie works for Biodex as a Clinical Administrator and Applied Clinician. She remains a part time treating clinician and consultant working with children up to three years of age.

David Wilcox, OTR/L

David Wilcox, OTR/L is an experienced clinician that has worked in the field of occupational therapy for more than 18 years. David started his career in 1998 at Moss Rehabilitation Hospital in Philadelphia treating an array of diagnoses such as traumatic brain injury, stroke, spinal cord injury, cardiac, pulmonary, and orthopedic conditions. He expanded his role from treating clinician to student supervisor, guest lecturer, mentor, and adjunct professor with specific focus on neuroscience and cognition.

David has been associated with Biodex since 2010, and recently joined the team in a full-time role. As a clinical educator, he provides operational in-services, continuing education accredited courses and workshops, and ongoing clinical support for Biodex's line of physical medicine and rehabilitation products.

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Kurt is the neurology coordinator at the University of Dayton's Doctor of Physical Therapy Program. He has published numerous scientific studies on the topic of balance and gait in individuals with neurological disorders. Kurt has also written several book chapters on the subject of exercise in the management of chronic neurological disorders. He has presented locally and nationally on the rehabilitation of individuals with multiple sclerosis, stroke, Parkinson's disease and peripheral neuropathy.

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1. Introduction, Purpose, and Considerations

Introduction

Biodex continues to put their customers first, by providing innovative medical technology and service excellence. It all begins with our belief in science-based solutions.

This Clinical Guideline for Cerebral Vascular Accident has been created to assist with improving patient rehabilitative outcomes, aid in providing greater treatment strategies, and enhance patient goal attainment.

Purpose

Clinical guidelines are systematically developed statements designed to assist health care providers make appropriate decisions for treatment. Biodex has created their clinical guidelines to assist in improving health care outcomes and efficiency of treatment, not to dictate the care of a particular patient. Health care workers are advised to make individual treatment decisions according to their own medical judgment in light of each patient's individual circumstances. Guidelines are intended to promote beneficial or desirable outcomes but not to guarantee a specific outcome.

Following completion of this Clinical Resource Guideline on Cerebral Vascular Accident the anticipated outcomes are as follows:

- Demonstrate a commitment to personal and professional growth with valid and reliable information.
- Guide health care professionals in the clinical decision-making process for developing a plan of care and intervention strategy when utilizing Biodex rehab technology.
- Communicate clear and concise guidelines to assist in the education of therapists and health care professionals.
- Assist in guiding health care providers to function as independent problem solvers in the practice environment relating to neurologic impairment and training on Biodex equipment.
- Supplement the theoretical learning of physical therapy pertinent to Biodex equipment testing and training with a carryover to functional activities.
- Integrate knowledge of neurological testing/training and physical therapy in order to modify treatment approaches that reflect the breadth and scope of health care practices.

Considerations

The clinician is expected to set patient goals and establish the direction of intervention based on patient examination and evaluation. The protocol aims to improve a patient's strength, balance and ambulation, as well as many other impairments. Patients, for whom these goals fit, may be candidates with the following considerations in mind:

- Use of this protocol is not a substitute for sound clinical judgment.
- Tests and measures are proposed but additional tests or measures may be needed.
- Patient inclusion in the interventions described in the protocol must depend on the clinician's interpretation of individual patient status.
- Progression is dependent on the patient's ability determined from reassessment (repeat examination and evaluation).
- In the instance of any uncertainty, the clinical judgement of the healthcare provider should always take precedence over following the sequence and steps of a clinical guideline.

2. Overview of Cerebral Vascular Accident

Cerebral Vascular Accident (CVA), or more commonly known as a *stroke,* is the sudden anoxia to the brain cells due to problems with blood supply. When blood flow to the brain is impaired, oxygen and important nutrients cannot be delivered. Blood flow to the brain can be disrupted by a blockage (an embolic/ischemic event). A rupture of an artery to the brain can cause a hemorrhagic event. Injury occurs and then death of brain cells occurs, with a common result of abnormal brain function. Most strokes are caused by embolic or ischemic episodes.

Classification and Pathophysiology

There are three types of stroke: embolic/ischemic stroke, hemorrhagic stroke and a transient ischemic attack, or more commonly known as a TIA.

Embolic/Ischemic Stroke

Embolic/ischemic strokes occur as a result of an obstruction within a blood vessel supplying blood to the brain. The underlying condition for this type of obstruction is the development of fatty deposits lining various vessel walls. This condition is called atherosclerosis. These fatty deposits can cause two types of obstruction.

Cerebral Thrombosis

Thrombisis refers to a blood clot that develops at the clogged part of the vessel.

Cerebral Embolism

A cerebral emboli generally refers to a blood clot that forms at another location in the circulatory system, usually the heart and large arteries of the upper chest and neck. A portion of the blood clot breaks loose, enters the bloodstream and travels through the brain's blood vessels until it reaches vessels too small to let it pass. A second important cause of embolism is an irregular heartbeat, known as atrial fibrillation. It creates conditions where clots can form in the heart, dislodge and travel to the brain.

Hemorrhagic Stroke

Hemorrhagic stroke accounts for about 13 percent of stroke cases. It results from a weakened vessel that ruptures and bleeds into the surrounding brain. The blood accumulates and compresses the surrounding brain tissue. The two types of hemorrhagic strokes are intracerebral (within the brain) hemorrhage or subarachnoid hemorrhage (anatomic space between the arachnoid mater and the pia mater). Two types of weakened blood vessels usually cause a hemorrhagic stroke: aneurysms and arteriovenous malformation.

- An aneurysm is a ballooning of a weakened region of a blood vessel. If left untreated, the aneurysm continues to weaken until it ruptures and bleeds into the brain.
- An arteriovenous malformation (AVM) is a cluster of abnormally formed blood vessels. Any one of these vessels can rupture, also causing bleeding into the brain.

Transient Ischemic Attacks

Transient ischemic attacks are caused by a blood clot. There is a major difference between a stroke and TIA; in the incidence of a TIA, the blockage is usually temporary. TIA symptoms usually occur rapidly and last a relatively short time. Most TIAs last less than five minutes; the average is about a minute. When a TIA is over, it usually causes no permanent injury to the brain.

Anatomy of the Brain

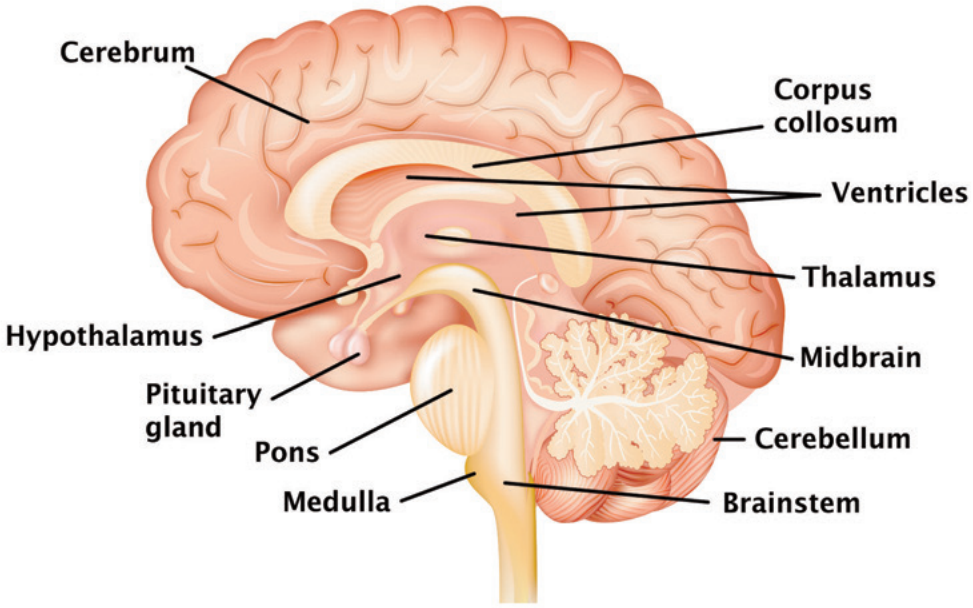
The Brainstem, Cerebrum and Cerebellum

The human brain weighs an average of 3 lbs. in men and 2 lbs. 12 oz. in women and has about 100 billion neurons. The brain's structure is almost complete at birth, although it continues to grow until about age 20, with increases in the size of individual cells and the amount of tissue connecting the neurons.

The brain is composed of three distinct parts; brainstem, cerebellum and cerebrum. Adjoined and structurally continuous with the spinal cord, the brainstem is responsible for life-supporting functions such as breathing, blood circulation and sleeping. The brainstem includes the midbrain, pons and medulla oblongata. The more developed cerebellum and cerebrum are responsible for higher level brain functions.

The cerebrum is the largest part of the brain and is composed of right and left hemispheres. It performs higher functions like interpreting touch, vision and hearing, as well as speech, reasoning, emotions, learning, and fine control of movement.

The cerebellum is a cauliflower-shaped structure, located just above the brainstem, beneath the occipital lobes at the base of the skull. The cerebellum receives information from the sensory systems, the spinal cord, and other parts of the brain and then regulates motor movements. The cerebellum coordinates voluntary movements such as posture, balance, coordination, and speech, resulting in smooth and balanced muscular activity. It holds an important piece for learning new behaviors.



Functions of the Brain

The cerebral hemispheres have distinct fissures, which divide the brain into lobes. Each hemisphere has four lobes: frontal, temporal, parietal, and occipital (Fig 3). Each lobe may be divided, once again, into areas that serve very specific functions. It's important to understand that each lobe of the brain does not function alone. There are very complex relationships between the lobes of the brain and between the right and left hemispheres. Each piece of the cerebral hemisphere has very distinct brain functions.

Frontal Lobe · Personality · Behavior · Emotions · Judgement · Planning · Problem solving · Speech: speaking/writing – Broca's area · Body movement · Intelligence · Concentration · Self-awareness	**Parietal Lobe** · Interprets language, words · Sense of touch, pain, temperature · Interprets signals from vison, hearing, motor, sensory and memory · Spatial and visual perception
Occipital Lobe · Interprets vision (color, light, movement)	**Temporal Lobe** · Understanding language (Wernicke's area) · Memory · Hearing · Sequencing and organization

Signs and Symptoms of a Stroke

- Confusion about where you are or what you're doing
- Difficulty speaking or understanding what others are saying
- Difficulty seeing in one or both eyes
- Trouble walking, dizziness
- Balance loss
- Sudden, severe headache that seems to come out of nowhere
- Inability to move on one side of the body ("hemiparesis")
- Severely limited movement
- Off-and-on numbness
- Unusual physical sensations
- Sensitivity to cold temperatures
- Memory loss
- Slowed or slurred speech
- Difficulty remembering words
- Unilateral facial droop

3. Physical Therapy in the Clinic: Evaluation and Rehabilitative Care Plan

Patients with a diagnosis of CVA present clinically with many different impairments depending on where the lesion in the brain has occurred. This specific variable can certainly influence a patient's ability to make functional gains. The primary impairments caused by stroke are many although the most common are hemiplegia, spasticity and aphasia. These impairments can and may present clinically with a decreased ability to perform daily functions such as communicating needs, dressing, bathing, or walking. These limitations in performing activities of daily living are not always directly related to impairments, but also to severity of the lesion, motivation, mood, coping skills, adaptability and learning ability of the patient. Also, prior medical history and pre-existing conditions can be a limiting factor during the rehabilitative phase of stroke.

Therapeutic interventions to improve sensory and motor performance after stroke vary considerably. Rehab outcomes can only be anticipated once the location of the lesion, severity level and primary / secondary impairments are determined. Once the evaluation process is completed, the framework for the rehabilitative care plan is then put in place. This is a most important step for identifying what strategies to utilize. The role of the rehabilitative care plan is to enable the clinician to produce best rehab outcomes and provide the most optimal and appropriate care to patients post stroke. The use of standardized tests and measures early in the rehab process establish the baseline status of the individual, providing a means to quantify change in function. Based on the initial evaluation findings and ongoing reassessment, the therapist determines the objectives for each session and develops a plan to meet the objectives. The plan should include the appropriate treatment type, extent of treatment, assistance levels and facilitatory needs. Frequency and duration must also be decided upon.

It is imperative the therapist obtains vital signs, including blood pressure, heart rate, and blood oxygen level through pulse oximetry. If the vital signs are within normal limits, proceed with the evaluation. If the levels are unstable for that patient the therapist should always use clinical judgement to take appropriate steps to assure safety.

The following steps are a guideline to move clinicians through the rehabilitative phases. In the instance of uncertainty, the clinical judgement of the healthcare provider should always take precedence over following the sequence and steps of a clinical guideline.

Evaluation

The evaluation starts with a chart review in which the therapist collects important information such as past medical history, location and extent of brain infarct, and prior functional level. The therapist will then perform various tests to determine present baseline functional levels, cognitive levels, motor and sensory status, tone and functional activities. The results of the chart review and evaluation will assist to develop the Rehabilitative Care Plan.

Components of the Evaluation May Include:

- **Range-of-Motion testing (ROM):** It is important to determine what the active movement the patient has, if any.
- **Manual Muscle Test (MMT):** A common standardized assessment designed to test muscle strength.
- **Skin assessment**: It is important to note skin color, moisture, temperature, texture and turgor. Also note vascular changes, edema, and lesions.
- **Sensory testing**: Common tests performed are to identify function of light touch, proprioception and pain/temperature.
- **Tone assessment:** Therapists to assess and grade for hypotonia and hypertonia, Typical testing is the Modified Ashworth Scale (MAS).

Prefunctional Activities

Evaluative activities that contribute to overall improved function should be assessed as noted below:

- **Supine to sit:** The ability to sit up from a supine position.
- **Sit to stand:** The ability to shift weight and maintain postural control when moving from sit to stand; anterior weight shift needed to assume upright.
- **Static sitting and/or standing balance:** Balance in a stationary position.
- **Dynamic sitting and/or standing balance:** Balance in lieu of any movement away from the static position.

Functional Activities

Evaluative activities that focus on common everyday tasks should be assessed as noted below:

- **Bed mobility:** Encourages mobility to engage core musculature in preparation for upright sitting and standing, and when rolling from side to side.
- **Transfers:** The process of moving from one position to another; transfers from one object or surface to another.
- **Ambulation:** The ability to walk from place to place independently with or without assistive device. Specific components will be looked at pertaining to symmetrical weight bearing, foot clearance, weight-shifting ability, hip/knee position when weight bearing and ankle/foot kinematics.
- **Stairs:** Evaluative activity that would be set aside for higher level functioning patients.
- **Activities of Daily Living (ADLs):** Evaluating the ability to engage in habitual activities such as bathing, dressing, grooming, and toileting.

Community Mobility:

Evaluative activities that may be set aside for patients functioning at high levels, perhaps in an outpatient setting. Some examples of navigating in the community include: up/down ramps, uneven surfaces, stair negotiation and other obstacles.

Patient and Family Education:

Providing detailed information to the patient and family is an integral part of the rehabilitation process, particularly when a patient is returning to home.

Common Primary Impairments as a Result of CVA

Neuromuscular impairments	· Abnormal tone could be variable levels of flaccidity or spasticity · Sensory deficits presenting as limitations in proprioception, kinesthesia, sensation · Limitations in motor control · Hemiparesis or hemiplegia · Presence of ataxia
Visual perceptual impairments	· Cortical blindness · Hemianopsia · Emergence of spatial relation disorders · Emergence of body scheme/image disorders · Agnosias · Apraxia
Swallowing impairments	· Dysphagia
Cognition and higher order cognition	· Limitations in attention · Limitations with memory · Limitations in safety awareness · Limitations in judgement · Presence of perseveration · Limitations in problem solving · Limitations in reasoning · Executive functioning such as organization and planning
Behavioral deficits	· Disinhibition · Depression
Communication deficits	· Aphasia · Dysarthria · Presence of auditory deficits · Limitations in reading comprehension and writing, pragmatics, and language skills

Direct Intervention

There are numerous approaches to stroke rehabilitation. Specific performance in any area is most likely to improve when motor activity is willful, repetitive and task oriented.

Stroke rehabilitation is multi-faceted and may include some or all of the following activities, depending on the part of the body or type of impairment. Some traditional activities include:

- **Postural awareness:** An awareness of the alignment and position of the body in relationship to gravity, center of mass, and base of support.
- **Motor learning:** A set of processes associated with practice and resulting to a permanent change in the capacity for skilled action.
- **Mobilization:** A manual therapeutic technique that fosters movement in stagnant tissues and joints, assists in breaking down scar tissue.
- **Strengthening motor skills:** Involves using exercises to help improve muscle strength and coordination.
- **Tone management:** Techniques that inhibit tone such as prolonged icing, firm pressure on tendons, and joint approximation. Facilitatory techniques such as quick stretch, resistance and vibration assist with triggering muscle contraction.
- **Positioning:** The physical placement of an individual's body into a position which promotes increased mobility and flexibility, assists with increased mobility and provides offloading and pressure relief.
- **PNF:** A set of stretching techniques commonly used in clinical environments to enhance both active and passive range of motion with the ultimate goal being to optimize motor performance and rehabilitation.
- **NDT:** A hands-on treatment approach used by therapists. This therapy uses guided or facilitated movements as a treatment strategy to ensure correlation of input from tactile, vestibular, and somatosensory receptors within the body.
- **Mobility training:** Bed mobility, transfer training, ambulation and stair training, may include learning to use walking aids, such as a walker or cane, or an orthotic to stabilize and assist ankle strength. This will help support body's weight during gait training. Patients will engage in movement strategies to build new neural pathways.
- **Constraint-induced therapy:** Also known as forced-use therapy. Involves restricting use of an unaffected limb while patient practices moving the affected limb to help improve its function.
- **Range of motion:** Exercises and other treatments to help lessen muscle tension (spasticity) and regain range of motion. Sometimes medication can help as well.

Equipment

Traditional Assisted

Assistive devices are a necessary factor to address when preparing the Rehabilitative Care Plan.

- Clinicians may assess positioning needs of the patient to optimize comfort, safety, and prevent breakdown of the skin. They will also assess whether an assistive device is needed and what type is required. Individualized decisions should be made regarding the prescription of adaptive and assistive devices such as wheelchairs and necessary accessories, various types of walkers and canes, hip/knee orthotics, and or ankle-foot orthosis. Orthotics are recommended only if other methods are not possible to assist in completing activities of daily living, and without, can compromise a patient's function.
- Many patients require assistive devices, adaptive equipment, mobility aids, wheelchairs and orthoses to maximize function after a stroke. Many types of adaptive equipment and durable medical devices are available. Type and level of impairment, function, and the characteristics of the patient's environment will be necessary information to determine the need for a particular item.
- It is recommended that the adaptive devices be used for safety and function if other methods of performing the task are not available.
- It is also recommended that lower extremity orthotic devices and/or walking devices be considered if ankle or knee stabilization is needed to improve the patient's gait and prevent falls.
- A variety of adaptive devices are available, including those for mobility – and many that will assist with ADLs. These devices should only serve as a supplement and should not be expected to take the place of the patient relearning the skill.

Technology Assisted

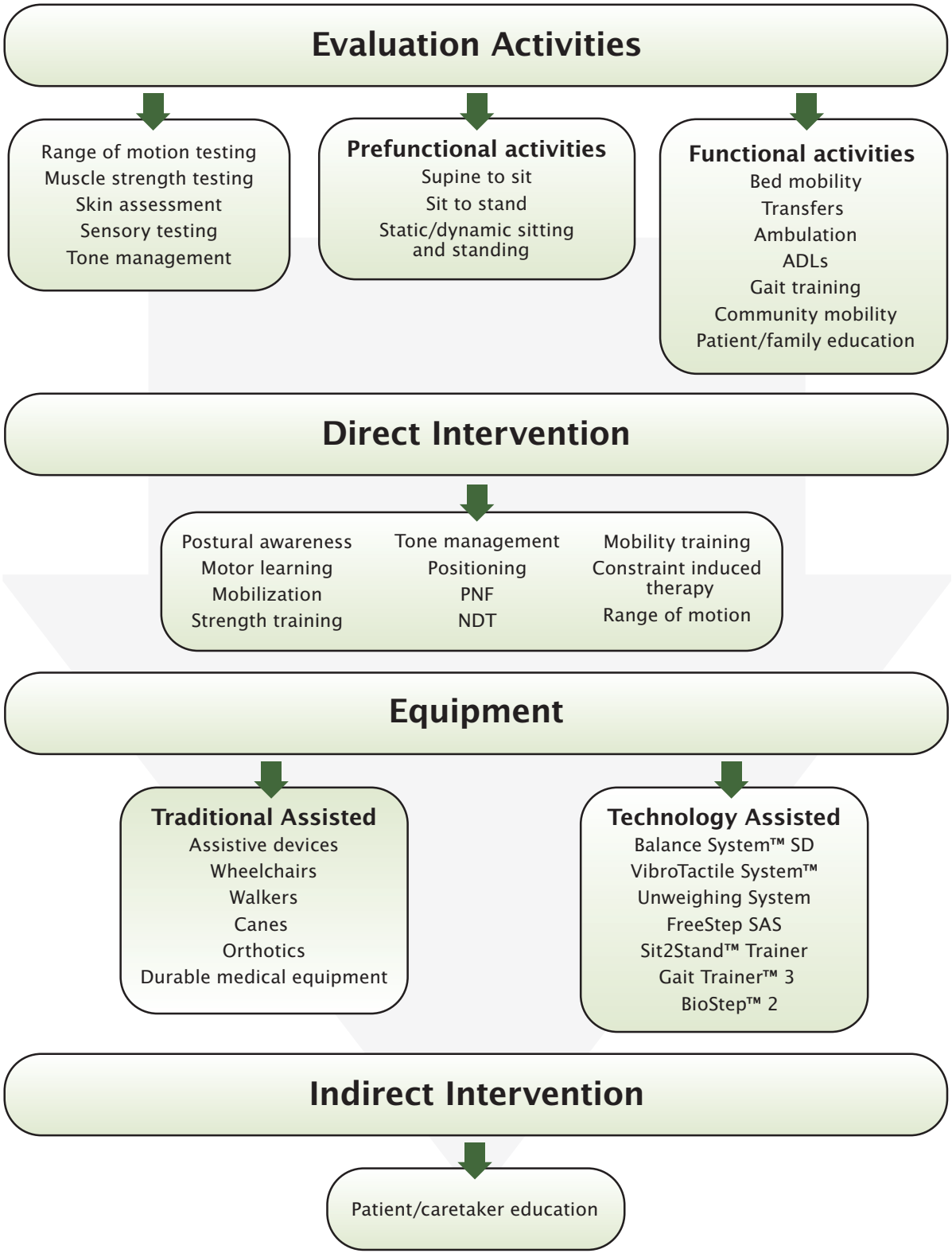
- The creation of technology based stroke therapy, combined with research guided protocols is helping patients every day. Traditional strength, balance, and gait training remains necessary during rehabilitation treatments. Although technology now plays a major role during a patient's recovery process, it also assists in creating greater therapist efficiency and measureable/reproducible treatment techniques.
- Technology aids, combined with advancing research based protocols, continue to optimize patient care.

Indirect Intervention

Education

A very important part of the rehabilitate care plan is stroke education for the patient, family and caregiver. Clinical education for the patients should be planned with a goal for optimizing learning. The end target goal is to assist the patient with resuming their quality of life.

Rehabilitative Care Plan for Remediation and Compensatory Strategies



4. Classifying Neurological Deficit Levels in Patients with CVA

Overview

Treatment on Biodex products can be multi-faceted and can vary considerably. Classifying the patient with CVA as having mild, moderate, or severe neurologic deficits, and in accordance with International Classification of Functioning, Disability, and Health (ICF), will assist clinicians in making the determination of which products to use and how to use them.

These classifications are not mutually exclusive. Patients may vary on a weekly, daily, and in some cases, hourly basis. Some may present with characteristics from a variety of categories. Important questions for clinicians to answer through observation and palpation include, but are not limited to the following:

- What do the movement patterns look like and how do they feel?
- Are compensatory strategies being utilized when performing an activity, and if so, is it a “normal strategy” (ankle, knee, hip strategy) or “abnormal” such as Trendelenburg gait?
- How much assistance, in the form of verbal cues or hands-on assistance, is required to keep the patient from losing balance?

In conjunction with informal clinical methods to identify impairments, therapists may consider using well documented tests and assessments with outcome measures to help determine the category their patient is in. Common assessment areas include, but are not limited to functional mobility, balance and ADLs. It is important for therapists to consider the information gathered during the initial evaluation when determining patients’ needs for specific tests and interventions.This will help guide the clinician in determining the best suited category and determine an effective treatment.

Below are examples of tests that are used in the clinic. Outcomes from a test, or a battery of tests may assist the therapist in determining the patient's level of impairment; minimal, moderate, or severe deficits.

Functional Mobility/Balance	Activities of Daily Living	Cognition
Berg Balance Test (measures functional mobility and balance)	Functional Independence Measure (FIM)	Glasgow Coma Scale
Balance System SD Tests: Fall Risk Screening Test, mCTSIB, Postural Stability, Motor Control (measures balance)	Barthel Index	Folstein Mini Mental (may not be appropriate for patients with aphasia)
Trunk Impairment Scale (TIS) (measures balance)		

CAUTION: Before any patient is to participate in cardiovascular activities, they must be medically stable and receive clearance from their physician.

Activity Areas and Common Outcome Driven Evaluation

Ambulation

It is indicative to use objective testing measures for ambulation for those patients who are status post CVA. The presence of sensorimotor and musculoskeletal impairments may contribute to poor postural control, balance and gait deficits. This can result in unsafe mobility with a potential for falls. A goal of treatment is to reduce falls by targeting impairments.

Six-Minute Walk Test (6MWT)

This test, which is standardized over ground, is also a part of the Gait Trainer's software. The test assesses numerous areas of gait including, walking speed, step cycle time, step length, coefficient of variation, and time on each foot.

Functional Independence Measure (FIM)

FIM is a common standardized ADL assessment tool that consists of 13 motor and 5 cognitive tasks. The assessment is scored on a 1-7 ordinal scale, with 7 representing complete independence. The two categories that directly assess mobility are locomotion and stairs.

Standing Balance

In upright standing, many individuals diagnosed with a CVA may have poor postural stability due to numerous motor and sensory disturbances. A goal of treatment is to reduce fall risk by targeting the impairments. Common assessments used in the clinic that may guide therapist in choosing the appropriate classification are tests on the Biodex Balance System SD, Berg Balance Scale, and Trunk Impairment Scale.

Fall Risk Screening Test

The Fall Screening Risk Test allows identification of potential fall candidates using the Biodex Balance System™ SD. Test results are compared to age dependent normative data. Scores higher than normative values suggest further assessment for lower extremity strength, proprioception, and vestibular or visual deficiencies.

Trial Time	Stance	Initial Platform Setting (Software v3.06 and earlier)	Ending Platform Setting (Software v3.06 and earlier)	Platform Setting (Software v.4.0.0 and later)
20 seconds	Bilateral	12	8	Static

Modified Clinical Test for Sensory Integration of Balance

The Modified Clinical Test of Sensory Interaction and Balance (mCTSIB) is a standardized test for Balance assessment on a static surface. The mCTSIB test protocol is well documented in the literature as an effective test for identifying individuals with mild to severe balance problems. Performed on the Balance System SD, The mCTSIB consists of four conditions. The test provides a generalized assessment on how well a patient can integrate various senses with respect to balance and compensate when one or more of those senses are compromised.

The Balance System also includes Postural Stability and Motor Control* tests – two additional and effective tests based on test-retest reliability (as opposed to normative data). Since these tests are not compared to normative data, the therapist may go into options and change the parameters of these two tests.

Number of Trials	Trial Time	Stance	Platform Setting
4 conditions	30 seconds per condition	Bilateral	Static

Postural Stability Test

The Postural Stability Test emphasizes a patient's ability to maintain center of balance. The patient's score on this test assesses deviation from center, hence a lower score is more desirable than a higher score.

Trial Time	Stance	Platform Setting
20 seconds	Bilateral	Static

** Prior to the release of the Balance System SD and BioSway version 4.x software, the Motor Control test was listed as Limits of Stability Test. Following the introduction of a new Limits of Stability test, the previous test was renamed as Motor Control*

Motor Control Test
This test challenges patient to move and control their center of gravity within their base of support. During each trial, patients must shift their weight to move the cursor from the center target to a blinking target and back as quickly with as little deviation as possible. The same process is repeated for each of the nine targets. This test is a good indicator of dynamic control. Poor control and inconsistencies, suggest further assessment for lower extremity strength, proprioception, vestibular, or visual factors

Berg Balance Scale
The Berg Balance Scale is a well-known, researched, and commonly used assessment to evaluate balance in this population. It consists of 14 items that range from standing up from sitting, to standing and balancing on one lower extremity. Item level scores range from 0 to 4 with a total maximal score of 36. Higher scores represent better balance.

Trunk Impairment Scale
The Trunk Impairment Scale (TIS) is designed to measure trunk motor impairment post-stroke by evaluating sitting balance – both static and dynamic – and trunk movement coordination.

Activities of Daily Living (ADLs)
The neurologic, muscular, cardiopulmonary, and/or cognitive deficits associated with CVA impact the most basic skills of everyday life, ADLs. Impairments such as decreased motor planning, limits of stability, and weakness can limit an individual's ability to perform their necessary activities of daily living. Common assessments used in the clinic that may guide therapists in choosing the appropriate classification is the Functional Independent Measure (FIM).

Functional Independence Measure (FIM)
The FIM is a commonly used assessment that looks at a person's performance with ADLs, mobility, and functional transfers. Other areas such as bladder and bowel management and cognition are looked at. The 18 items assessed are scored from one to seven, with one representing total assistance and seven representing independence. Scoring ranges from 18 to 126.

Barthel Index
The Barthel index outlines ADL and mobility through ten scaled factors – including dressing, bathing, eating, walking, and climbing stairs – in order to determine the ability of the patient to live at home with a level of independence. Each variable is scored from one to ten, with a higher number representing increased capability of independence.

Cognition
A third area that therapists may choose to assess to help classify their patients and determine an appropriate treatment regimen is cognition. Cognitive impairments are quite common in patients who have experienced a CVA. Cognitive impairment has a large impact on activity participation. Examples of impairments are decreased memory, attention, reasoning, problem solving, safety awareness, judgment, impulsivity, and poor executive functioning (e.g. planning, organization, self-monitoring, and impaired evaluation). A common assessment used in the clinic that may guide therapists with assessing cognition is the Glasgow Coma Scale (GCS).

Glasgow Coma Scale (GCS)
The GCS provides method of assessment for the conscious state of a person by scoring eye, verbal and motor function. A patient is given a score based on scaled criteria with a range between 3 and 15 with a higher number representing increased awareness.

Folstein Mini Mental
The Folstein Mini Mental examination scores cognition using a scaled system measuring orientation, registration, attention and calculation, recall, and language. A score of 30 is the maximum, with a score of 23 or below representing a cognitive deficit.

Classification of the Patient with Neurological Involvement

Patients with Profound Impairments – Requiring Maximal Assistance

Patients classified at this level may have significant neurologic, muscular, cardiopulmonary, and/or cognitive deficits that restrict patients' activity participation, such as ambulation and ADLs. These impairments warrant physical assistance between maximal and total. Patients classified within this level may or will:

- Not be deemed appropriate for any standing balance tests.
- Require the assistance of two to ambulate less than 50 feet (locomotion/walking FIM score of 1).
- Require total assistance or maximal assistance for transfers (transfers FIM scores of 1 or 2).
- May require maximal or total assistance to participate and complete ADLs (FIM scores of 1 or 2).
- Demonstrate heightened alertness while behavior is bizarre with periods of gross attention to the environment. Patient may be distractible.
- Be classified as having a significant CVA on the GCS.

What a therapist may see or feel in patients requiring maximal assistance. Patients may or will:

- Have poor static and dynamic balance, requiring total to maximal assistance to remain upright in standing and sitting. The patient may tolerate standing for less than one minute with total to maximal assistance.
- Have significant fear of movement or poor volitional control.
- Have minimal or no ability to tolerate weight bearing through the neurologically involved sides with therapeutic assistance.
- Have poor attention span, but should be able to follow one to two step commands.
- Have significant impairments to the visual /perceptual system(s) resulting in neglect, inattention, and or poor midline orientation.

Patients with Moderate Impairments – Requiring Moderate Assistance

Patients classified at this level may have more predominant neurologic, muscular, cardiopulmonary, and/or cognitive deficits that restrict patients' activity participation, such as ambulation and ADLs. These impairments warrant physical assistance at a moderate level. Patients classified within this level may or will:

- May be able to walk between 50 and 150 feet with maximal assistance or 150 feet with moderate assistance (locomotion/walking FIM of 2 or 3).
- Score well outside the normative limits in most or all testing items on Gait Trainer's version of the Six-Minute Walk Test. Patient may not be able to finish the test.
- Be able to ascend and descend 4 to 6 stairs doing less than 25% of the task and with 2 therapists to assist or require maximal assistance of 1 (Locomotion stairs FIM score of 1 or 2).
- May require moderate assistance with some, many, or all aspects of ADLs (FIM score of 3).
- Follow simple step directions consistently while demonstrating good gross attention, but is easily distractible or attend for about 30 minutes but has trouble concentrating when it is noisy or when the activity involves numerous steps.

What a therapist may see or feel in the person requiring moderate assistance. Patients may or will:

- Be able to stand 1-3 minutes with moderate assistance.
- Have fear of movement, requiring moderate assist from the therapist with any movement.
- Require moderate therapeutic assistance to tolerate weight through one or both sides of body.
- Have minimal or moderate impairments to the visual/perceptual system(s) presenting as neglect, inattention, and/or limited midline orientation.
- Begin to demonstrate non-isolated gross volitional control of the neurologically involved side.
- Start to develop synergistic movements.
- May not have visual perceptual deficits.

Patients with Minimal Impairments - Requiring Minimal Assistance

Patients classified at this level may have recognizable neurologic, muscular, cardiopulmonary, and/or cognitive deficits affecting their ability to participate independently and safely in important activities, such as ambulation and ADLs. These notable impairments warrant physical assistance at a minimal level. Patients classified within this level may or will:

- Demonstrate minimal balance deficits while participating in various therapeutic activities and items on the Berg Balance Scale, such as sit to stand, standing unsupported, stand to sit, transfers, retrieving objects from the floor, and turning to look behind. Scores may fall between 21 and 40 which qualifies them as medium risk for falls.
- Not qualify for Balance System SD or BioSway tests because of the continued hands on assistance required.
- Be able to walk at least 150 feet with minimal assistance or supervision (locomotion/walking FIM scores of 4 or 5).
- Score near or within the normative limits in most or all testing items the Gait Trainer's version of the Six-Minute Walk Test.

- Be able to climb and descend 12 to 14 stairs with moderate or minimal assistance or with supervision (locomotion stairs FIM scores 3, 4, 5).
- Require minimal assistance with at some, many, or all aspects of ADLs (FIM score of 4).
- Attend for about 30 minutes but has trouble concentrating when it is noisy or when the activity involves numerous steps or follow multi-step command. They may be able to learn new information but may require guidance with decision making. They may demonstrate poor judgement in new situations.

What a therapist may see or feel in patients requiring minimal assistance. Patients may or will:

- Require incidental tactile and verbal cues for alignment
- Tolerate between 3-5 minutes of standing with minimal assistance to supervision.
- Demonstrate increased confidence with movement and may only require minimal assistance to supervision from the therapist to complete activities.
- Require minimal assistance and/or verbal cues to weight bear through one or both sides.
- Be able to produce gross synergistic movements with evidence of emerging isolated movement control.
- Have minimal or no impairments to the visual/perceptual system.

Patients with Minimal Impairments – Requiring Supervision

Patients classified at this level may have greater ability for neurologic, muscular, cardiopulmonary, and/or cognitive functioning, but they still may not be able to participate independently and safely in many areas. Ambulation, ADLs. dynamic balance may be effected and may warrant therapist supervision.
Patients classified within this level may or will:

- Demonstrate higher level dynamic balance deficits when participating in various therapeutic activities and items on the Berg Balance Scale, such as sit to stand, standing unsupported, stand to sit, transfers, retrieving objects from the floor, and turning to look behind. Scores may fall between 41 and 56 which qualifies them as low risk for falls.
- Demonstrate decreased neuromuscular control leading to scores that are slightly, moderately, or at times, well outside normative values on the Balance System SD's Fall Risk Test.
- Elicit increased sway that may contribute to scores that are slightly, moderately, or at times, well outside the normative score values on the Balance System SD's and/or BioSway's mCTSIB Test.
- Demonstrate atypical weight distribution output is objectively captured in the scoring percentages on the Balance System SD's and /or BioSway's Postural Stability Test.
- Elicit atypical movements within the sway envelope in some or many directions may lead to scores that are slightly, moderately, or at times, well below the goal scores imbedded in the software on the Balance System SD's and/or BioSway's Motor Control Test.
- Be able to walk at least 150 feet with supervision (locomotion/walking FIM score of 5).
- Score near or within the normative limits in most or all testing items on Gait Trainer's version of the Six-Minute Walk Test.

- Be able to climb and descend 12 to 14 stairs with supervision (locomotion stairs FIM score of 5).
- Require supervision with at least some aspects of ADLs (FIM score of 5).
- Be able to handle multiple tasks simultaneously in all environments but may require periodic breaks and accurately estimates and adjusts to task demands (characteristics of LOCF Level X).
- Be classified as having a mild TBI on the GCS.

What a therapist may see or feel in patients requiring consistent supervision. Patients may or will:

- Require an occasional verbal cue for alignment.
- Stand greater than 5 minutes without physical assistance.
- Demonstrate a functional level of confidence with mobility and is independent with most activities.
- Be able to weight bear on one or both sides with no greater than tactile and verbal cueing.
- Demonstrate improved isolated motor control.
- Continue to elicit minor synergist patterns interfering with function and mobility.
- Be able to ambulate with or without an assistive device with no greater than tactile and verbal cueing; distance can remain limited.
- Have minimal or no impairments to the visual/perceptual system.

5. Balance and Mobility Classification Reference

CAUTION: Before any patient is to participate in cardiovascular activities they must be medically stable and receive clearance from their physician.

Beginner Activities – Postural Stability and Symmetry

Applicable for Profound to Moderate Neurological Involvement

The focus for this category will be on maintaining good static alignment and symmetry under a variety of environmental and sensory conditions. These patients will generally not be able to participate in any testing regimens. They are working on their mat skills, transfers and range of motion. They are typically focused on improving their postural stability in sitting with assist and identifying their midline, as well as attempts at standing. They are generally getting used to placing weight through the neurologically involved side. To assist with standing activities use of the unweighing harness may be a possibility as well as ensure a safety mechanism against falls. Patients at this level usually continue to require moderate assist to maintain sitting in the upright position. They may be able to stand for 1-3 minutes with the Unweighing System and/or other support.

Biodex Balance System SD

The following is a list of the sensory and environmental conditions that can be altered when using the Biodex Balance SD. These modifications can be utilized individually or in combination to provide the optimal level of challenge for each specific patient as their rehab progresses and they begin to make functional gains.

Recommendations

- **Base of Support Modification:** Alter foot position – wide/narrow
- **Hand Position:** Holding rails, hands touching rails(palms open), hands above rails (only touching rails when needed), hands at side
- **Surface Platform Modifications:** Add foam, alter foot placement
- **Vision Modifications:** Eyes open (EO), reduced or altered vision, Eyes closed (EC)
- **Head Movements:** Vertical, horizontal, diagonal, alter amplitude and speed as tolerated
- **Dual Tasks Activities:** Add increasing cognitive demand (backward counting, answering questions)

Unweighing System and Gait Trainer 3

To participate in Body Weight Support Treadmill Training (BWSTT), it is recommended that patients meet minimal requirements. Patients should be able to follow simple two-step commands and have sufficient vision to see the Gait Trainer screen, as well as the ability to attend to task with limited distractibility. The patient must also be able to communicate (verbally or non-verbally), or demonstrate sign of tolerance effectively.

Take note of any external bowel and bladder management devices or other medical devices such as a Foley catheter, colostomy bag, suprapubic catheter, and/or percutaneous endoscopic gastrostomy tube. These devices may interfere with the harness while the patient is participating in unweighted training. Make the necessary adjustments as clinically indicated.

The patients at this mobility level either cannot stand or may require maximal/moderate assistance to stand. They have a quick fatigue rate/poor endurance. Once donned (please see The BWSTT Clinical Guideline for specifics donning and doffing instructions) the unweighing harness and system can be helpful to assist in standing for short periods of time. The patients can stand at a walker or be mechanically lifted to stand with utilization of a high/low table. Through controlled reduction of weight bearing during upright standing and ambulation, the unweighing system attempts to provide postural support and promote coordination of the lower extremities. The decrease in weight bearing is intended to minimize the stress and demands on the muscles, in theory, allowing the patient to develop more effective and efficient movement strategies.

Recommendations

- For the profoundly affected patient initiate the treadmill at 0.5 percent. The therapist then assesses gait kinematics and postural control while monitoring vital signs. Adjustments may need to be made based on patients alignment and tolerance level.
- Gait training performance may be variable. It is important to obtain a baseline by having the patient participate, as per individual tolerance, between one and five minutes initially.
- Therapist examines and assesses the patient during the baseline ambulation trial.
- If vitals are unstable and/or the patient is not feeling well, the clinician should take the necessary steps to assure patient safety.
- Based on clinical presentation of the patient, the therapist uses clinical judgement as to when to adjust the speed and step length.
- Two trials (2-3 minutes) in duration is recommended for initial contact. Frequency increased or decreased as per patient response.

Intermediate Activities – Dynamic Weight Shifting

Applicable for Moderate to Minimal Neurological Involvement

The focus for patients in this category will be on volitional control of core musculature and extremities. The goal for patients at this level will be to display voluntary weight-shifting activities. Those persons at this intermediate category are rebuilding their endurance and tolerance to activity. They are able to perform assisted standing activities for increased time. Their dynamic sitting and standing balance is usually progressing. They have increased the ability to weight bear on the impaired extremity and may be taking a few steps. They may be able to complete approximately 3-5 minutes of training before requiring rest. With usage of the Unweighing System and Gait Trainer, they can walk short distances.

BioStep 2

The BioStep can be used to promote improved tolerance to activity, improved endurance as well as assist with range of motion and strengthening. This level of patient is beginning to tolerate longer therapy times. They are regaining their mobility and isolated movement control. Initial bouts of activity on the Biostep should be limited.

Recommendations

- Patients should rate their perceived exertion from the "Borg CR10 scale (see page 8-6).
- Levels of perceived exertion should be at an optimal level of 4-6 exertion.
- Recommended initial trials of activity should be between 2 and 5 minutes each trial.
- The patient's vitals should be assessed pre and post exercise.

Biodex Balance System SD

Initially patients can focus on simple anterior/posterior and medial/lateral weight shifting with visual feedback. The Motor Control training mode can be used to challenge both A/P and M/L weight shifts as well as diagonal weight shifting. Recommended balance activities are below. Within each training mode, the difficulty level can be adjusted by varying the platform stability.

Recommendations

- **Weight-Shift training:** Adjust A/P and M/L skill level and platform stability.
- **Motor Control training**: Adjust target skill level and platform stability.

Unweighing System and Gait Trainer

The patient may tolerate treadmill training time utilizing the unweighing harness to improve postural control via unweighing the body up to 40 percent of body weight. (See the BWSTT guideline on how to safely utilize the Unweighing System harness, determine percent offloading and navigate through gait trainer operations.) The Gait Trainer combined with the Unweighing System can be used to for pregait activities, working on average step length, step length variability and time spent on each foot for improving symmetrical weight bearing. The patient can also work on speeding up and slowing down their walking speed to address their cadence time and step length capabilities.

Recommendations

- Initiate training based on the patient's self-selected speed determined from the Ten Meter Walk Test performed over ground. Therapist observes and assesses gait kinematics, postural control and facilitates in areas needing support.
- Vital signs are monitored for any signs of distress and are adjusted accordingly.
- The speed of the Gait Trainer above the patient's comfortable self-selected speed by 0.1-0.2 mph. The patient must demonstrate optimal gait kinematics and endurance with little compensatory strategies. The therapist evaluates the patients gait presentation and varies speed and offloading percentage accordingly.
- Based on clinical presentation of the patient, the therapist uses clinical judgement as to when to adjust the speed.

Advanced Activities – Reactive Postural Control Training

Applicable to Supervised-Independent Neurological Involvement

Advanced rehab activities require the patient to respond to unplanned or unanticipated challenges during mobility. This type of control is essential for reducing fall risk during unintended loss of balance, such as slipping or tripping, while performing dynamic activities. Patients in this category display increased postural control in sitting and standing. In a percentage of the stroke population synergistic movement patterns are becoming replaced by isolated muscle control. There is an increased tolerance to activities. Patients in this recovery phase can begin to work on their endurance levels utilizing the BioStep 2, and address lower extremity strength on the Sit2Stand Trainer. Training on the Unweighing System and Gait Trainer 3 will continue to work on the components of gait. For the more advanced patients the focus here will be more time spent practicing over ground activities. These activities will assist patients in regaining their functional ability within their home. The Balance System SD will continue to assist in improving core stability, upright postural control and anticipatory control.

BioStep 2

The patient at this mobility level has improved although they will continue to address their deficits; whether it be a level of fatigue, or compromised strength due to increased tonal patterns. The patient is now ambulatory but they may continue to exhibit less than optimal endurance and isolated muscle control. The BioStep and Sit2Stand Trainer are ideal for patients who remain weak, deconditioned or have poor coordination due to abnormal tone.

Recommendations

- Vitals to be monitored by clinician.
- Borg CR10 scale to be used to monitor exertion levels – maintain levels between 4-6.
- Based on clinical presentation of the patient, the therapist uses clinical judgement as to when to request increased rpms.
- Recommended total duration is 10 minutes with a perceived exertion not to exceed level 4-6. (Borg CR10). Duration of BioStep activity is based on patient reports and therapist clinical judgement.

Sit2Stand Trainer

The Sit2Stand Trainer can be used to assist in regaining muscle strength and endurance. It can also assist in isolated muscle control which is imperative to a patient recovering from a Cerebral Vascular Accident. The sit to stand movement is the precursor to walking and function (See chart on page 8-1 for more information.)

Recommendations

- **Endurance Training:** 3-4 days per week, short rest periods.
- **Range of Motion:** 5-6 days per week, major muscle groups.
- **Resistance Training:** 2-3 days per week, slow and controlled movements.

Balance System SD

Patients are utilizing all balance systems in this category of rehabilitation. Core stability in addition to proprioception, vestibular and vision are called in to assist the patient to remain upright due to unexpected variables affecting stability levels.

Recommendations

- **Random Control Training:** Adjust target diameter, target speed and platform stability as tolerated.
- **Ball/object toss activity:** Position patient on platform facing away from the display unit.
- **Reaching and functional activities:** Face patient away from display screen and have patient perform reaching activities. Modify location, weight, size or location of object and platform stability as tolerated.
- **Therapist induced perturbations:** Adjust platform stability to desired level in the Postural Stability Training mode. Therapist can induce unexpected perturbations by pushing gently on the patient's torso or using their foot to vary the platform. Use a spotter or harness support for fall protection at all times during this task.

Unweighing System and Gait Trainer 3

This category of neurological impairment addresses functional activity while still maintaining safety. The patient may be supervised or independent on the Gait Trainer. Based on gait impairment, there may also be a need for support via the Unweighing System. Facilitatory techniques should be used as needed. Activities of focus will be performance of variable components of gait while maintaining an upright and aligned postural control. Step length can be altered to improve symmetry. Speed can be altered to address cadence. The patients can perform gait activities in variable planes.

Recommendations

- Introduce obstacles onto the Gait Trainer belt at slow speed.
- Incorporate changes in speed, direction and visual field flow to simulate functional activities.
- Set gait speed goals.
- Introduce the patient to unsupported ambulation on the Gait Trainer.

Free Step SAS (Supported Ambulation System)

The advanced level of neurological patients presents with overall improved function in balance and ambulation. They may continue to experience residual tone, uncoordinated muscular activity, range of motion deficits and other functional limitations. The FreeStep provides a safe environment for patients to participate in full weight bearing activities while addressing functional activities but with a decreased fall risk. It assists with over ground activities and will free up therapists to facilitate mobility and analyze movement patterns.

Recommendations

- Ball toss, reaching, and functional activities to offset patient's dynamic balance.
- Turning activities can be incorporated into gait training to increase stability.
- Navigating various surfaces to assist with proprioception levels.
- Obstacle courses create a mock functional environment to assist with patients re-entry into the home and the community.
- Unilateral lower-extremity exercises when harnessed into the FreeStep will provide a safe environment to continue strengthening the involved extremity.
- Using a hi/low table, address developmental sequences to promote scapula, pelvic and core stability.
- Stair climbing for strength, coordination and endurance activities.

6. Incorporating Technology into Treatment

Overview

There are many studies that support technology as an effective compliment to traditional therapy approaches. The goal of rehab technology is to empower clinicians to take responsibility and control of the environment and facilitate physical and cognitive recovery. Also, with technology based treatment there is a component of learning-based practice that assists and drives neural adaptation and neural reorganization. Additionally, risk of injury is minimized and training provides alternative options when traditional approaches are not effective. Biodex's line of physical medicine products, in conjunction with their coinciding learning tools such as clinical guidelines and elearning online education courses, clinicians are empowered to improve upon their own clinical practice and intervention approaches with the overall goal of improving patients' quality of life and activity participation.

CAUTION: Patients should be medically stable before starting an active program of physical therapy. Tests and measures used in this Guideline should only be performed with medically stable patients.

Before Getting Started

Stability should be achieved in:

- Prescription medication
- Blood pressure, circulation, and respiration
- Mental capacity for cognition and behavior
- Bowel/bladder control
- Decreased or absent sensation and proprioception should also be noted

Patient Considerations

Treatments should be modified based on the patient's response and with the patient's well-being in mind. Breaks should be incorporated throughout the treatment session as needed, especially with patients who have cardiac, pulmonary dysfunction, and/or general deconditioning. When using the Unweighing System and/or FreeStep, consider the patient's bowel and bladder status when using this equipment. The upright position and harness may affect the patient's control.

Biodex Equipment

Balance System SD

Featuring seven test protocols, six training modes and intuitive touch screen operation, the Balance System SD allows testing and training in both static and dynamic formats. Extremely versatile, it can assess neuromuscular control by quantifying the ability to maintain dynamic bilateral and unilateral postural stability on a static or unstable surface.

The Balance System SD also is used to enhance kinesthetic abilities that may assist with impaired proprioception and encourage motor control associated with TBI. Patients are challenged to shift and control their center of gravity through various rehabilitative training strategies.

VibroTactile System

As an optional enhancement to the Balance System SD, the VibroTactile System offers an additional form of sensory feedback to help patients detect changes in postural sway. Using wireless technology, the tactile belt responds with vibration when patients reach specific targets or sways outside of the therapist-set parameters.

Unweighing System

The Unweighing System can reduce the amount of the patient's weight and enables proper upright posture. The Unweighing System is used to remove a pre-determined portion of the weight load from the patient's legs. It can also provide support during ambulation and balance training for those patients who are functioning at higher levels.

FreeStep SAS (Supported Ambulation System)

The FreeStep SAS is an overhead track and harness system that provides a safe ambulation and balance training environment for both patient and therapist. The FreeStep assists with minimizing a patients fears of falling and allows the therapist to freely assist their patients.

Sit2Stand Trainer

The Biodex Sit2Stand Trainer helps the therapist guide patients through the seated to standing motions, in a safe environment. By repeating the motions, a patient builds both lower- and upper-body muscular strength and endurance, improves flexibility and ultimately maintains/gains independence.

Gait Trainer 3

The Gait Trainer 3 provides audio and visual biofeedback of step length and step speed. These features assist with normalizing impairments in gait.

The Integrated Music Therapy option encourages neuroplasticity through Rhythmic Auditory Stimulation (RAS) and pattern sensory enhancement (PSE) via music therapy-informed compositions.

BioStep 2

The elliptical motion of the BioStep is naturally smooth and continuous. It promotes reciprocal upper and lower extremity patterning. The rotating seat and step-through design provide easy and safe entry and exit. Upper or lower extremity exercises can be performed singularly to accommodate fatigued patients.

medBike

Motion exercise for those with physical limitations or wheelchair users. Motion training of medBike helps loosen and strengthen muscles, and reduce spasticity.

The Pedal Assisted Mode at the higher rpm levels that the medBike can offer, up to 90 rpm. The Continuous Control System avoids overstraining the lower- and upper-leg muscles, creating safe exercise conditions.

System 3 and 4

Designed for overall multi-joint strengthening, range of motion and speed specific training, the System 3 and System 4 accommodate a wide variety of positions and exercises. In addition to standard attachments, lightweight carbon fiber hemiparetic attachments are engineered for isolated strengthening in a gripless pattern for elbow ex/flex, wrist ex/flex, shoulder ex/flex, ab/ad and int/ext rotation.

7. Traditional Interventions

Overview

A multi-faceted approach exists in the treatment of patients with CVA. Early in rehabilitation, a remediation approach to target specific impairments and improve overall function is highly recommended. Examples of activities that are considered under the umbrella of a remediation approach to treatment are, but not limited to, improving postural control, endurance, motor control, strength. If it is clinically determined that movement and sensory deficits persist and cannot be remediated, a shift toward compensatory training may be indicated. Whether the treatment is remediation or compensatory, it is imperative that family members and/or designated caregivers (i.e. nurse's aide) are a part of the patient treatment and overall rehabilitation plan. In many cases, patients are discharged home where their care will be taken over by family and/or caregivers. Whereas PTs may focus on mobility and transfer training, OTs may educate family members and/or caregivers with ADL and IADL techniques, cueing strategies, or environmental setup, and/or adaptations. Whatever actions therapists choose to take, education should be consistent and systematic to not only maximize patient function and activity participation, but to assure patient and caregiver safety upon discharge.

Treatment Intervention

Comparing the Bottom-up vs. Top-down Treatment Approaches

The bottom-up approach, entails using specific methods, such as therapeutic exercise and activities to target impairments. A relatively new approach used in the clinic, which the ICF describes as a top-down approach, is called the task-oriented treatment approach (TOT). Instead of targeting specific impairments, the task-oriented approach focuses on activity limitations and skill acquisitions that are important to the patient. Based on models of motor control, motor learning, and behavioral neuroscience, this goal-oriented approach focuses on active participation and the ability to gain skills as crucial components of a patient's recovery. Below are principles that task-oriented training adopts:

- Individualized decisions should be made about the prescription of adaptive and assistive devices (cane, walkers, commode chairs, reachers, etc.).
- The central nervous system is highly interactive, and movements are complex, so an intensive task-oriented approach is recommended.
- For motor learning to occur, influencing functional performance, there must be active engagement from the patient.
- Movements should happen with intent, be goal directed, practice, repetition, and involve cognition.
- Movements should be variable, dynamic, and under an array of conditions, to optimize motor learning.
- Skill acquisition occurs with the combination of movement patterns, using numerous muscles and joints.
- Training should be intense and consistent with the occurrence of some type of feedback.

Examples of traditional therapy interventions that fall within top-down or bottom-up treatment principles that therapists may be familiar with when treating patients with TBI are listed below.

Common bottom-up, impairment-specific approaches to treatment

- **Soft tissue mobilization:** A manual therapeutic technique that fosters movement in stagnant tissues and tight joints.
- **Strengthening motor skills:** Involves using exercises to help improve muscle strength and coordination.
- **Proprioceptive Neuromuscular Facilitation (PNF):** A set of stretching techniques in diagonal directions that are commonly used in clinical environments to enhance both active and passive range of motion with the ultimate goal being to optimize motor performance and rehabilitation.
- **Neurodevelopmental Technique (NDT):** A hands-on treatment approach used by therapists. This therapy uses guided or facilitated movements as a treatment strategy to ensure correlation of input from tactile, vestibular, and somatosensory receptors within the body. Therapists use the NDT approach to help reduce hypertonia and/or spasticity.
- **Range of Motion**: Active, active assistive, passive range of motion performed by patient and/or therapist with the goal of maintaining joint mobility.
- **Stretching:** A common practice for occupational and physical therapy. The focus here is to promote muscle fiber lengthening and decrease any pain associated with decreased mobility or hypertonia and help achieve full joint ROM.

Common top-down, task-oriented approaches to treatment

- **Mobility and functional transfer training:** May include learning to use walking aids, such as a walker or canes, or a plastic brace (orthotic) to stabilize and assist ankle strength to provide added support as the patient relearns gait.
- **Training:** ADLs or Instrumental ADLs (IADLs).
- **Balance training:** Beginning with postural stability and alignment, working up to dynamic postural control and higher level activities such as reactive postural control and dynamic gait activities.
- **Constraint-induced therapy:** Also known as forced-use therapy, involves restricting use of an unaffected limb the patient moves the affected limb to help improve its function. It is considered a special a special class of task oriented training.

The Use of Assistive Devices in Treatment

As stated above, therapists may need to evaluate for assistive devices from the onset of the initial evaluation. In a rehabilitation setting for example, determining the wheelchair type and cushion may be required from the onset of the evaluation assure patient comfort, safety, and minimize potential issues that occur quickly, such as skin breakdown. When standing the patient for the first time, it is often common for therapists to keep assistive devices, such as a hemi-walker or standard walker, close by to use with the patient when they stand or walk with them the first time, and moving forward as part of their treatment. It is recommended that therapists take the below listed recommendations into consideration when utilizing any assistive device during patient treatment:

- The location, type, and level of impairment, will be necessary to determine the need for a particular device. Clinicians must use their sound clinical reasoning to determine which additional devices may be needed or taken away to optimize overall improved function.
- Assistive and/or adaptive devices should be used for improved safety and function if other methods of performing the task are not available.
- Lower extremity orthotic devices for example, may be considered if ankle or knee stabilization is needed to improve the patient's gait and prevent falls.
- Rolling, standard, hemi-walkers, quad canes, and single-point canes are other examples that provide assistance with common impairments with TBI, such as decreased balance, lower extremity strength, and endurance.

8. References

Sit-to-Stand Exercise Recommendations

Modality	Resistance Training	Power Training*	Range of Motion Training	Endurance Training
Frequency	· 2-3 days/wk · Slow and controlled movements	· 3-4 days/wk	· 5-6 days/wk · Major muscle groups	· 3-4 days/wk
Volume	· 1-3 sets; 8-12 reps · 1 minute rest between reps · 60%, 1 RM	· 1-3 sets · 2-3 minutes per session	· Progressive as per patient tolerance	· 1-4 sets based on patient tolerance · 12-15 reps · 15-20 second rest between reps
Intensity	· 5 on Borg CR10 Scale	· 6 on Borg CR10 Scale	· 3 on Borg CR10 Scale	· 5 on Borg CR10 Scale
	· 4-6 sec repetition · 50%, 1 RM	· Set 1-10 repetitions · 40% 1 RM (BWA), with UE support · Increase to 50% after subject displays efficient skills	· 15 sec repetition	· 50%, 1 RM
Requirements for safety and maximal efficacy	· Slow speed · No ballistic movements · Day of rest between sessions · Good form without muscle substitutions · Decrease percent RM when poor form is noted	· Increase workload progressively to maintain relative intensity · · Increased rep speed · Work modified mid range of motion	· Move slowly through available range of motion. · Hold at end range for 1-2 seconds for increased mobility	· 5 on Borg CR10 Scale · Shorter rest periods · Increase workload progressively to maintain relative intensity · Progress difficulty as tolerated

* This facilitates power, enables the patient to learn how to “jump up” and generate more force in a functional task, and provides some success, which leads to dopamine release and enhanced expectancies.

Cerebral Vascular Accident Exercise Protocols Based on Levels of Impairment

Beginner Activities	
Balance System SD	· Base of support modifications: Alter foot position. · Modification of hand placement: Hands on, hands lightly touching, hands off. · Surface platform modifications: Alter foot placement, alter platform stability. · Visual modifications: Eyes open, reduced or altered vision, eyes closed. · Head movements: Vertical, horizontal, diagonal, alter amplitude and speed as tolerated. · Dual task activities: Add increasing cognitive demand (backward counting, answering questions).

Unweighing System and Gait Trainer 3	· For profoundly affected patients:
	  · Initiate the treadmill at 0.5 percent
	  · Assess with gait kinematics and postural control while monitoring vital signs
	  · Adjust speed based on patient alignment and tolerance level
	· Gait training performance may be variable: Obtain baseline by having patient, as tolerated, participate between 1 and 5 total minutes.
	· Therapist examines and assesses the patient during baseline ambulation trial.
	· If vitals are unstable, or patient is not feeling well, clinician. to take necessary steps to assure patient safety.
	· Vary speed and step length based on clinical presentation of patient.
	· Two baseline trials 2-3 minutes: Alter duration as per patient response.

medBike	· Pedal assist mode and passive mode for patients with maximal involvement. · One to two trials 2-3 minutes while closely monitoring vitals.

Intermediate Activities	
Balance System SD	· Weight-shift training: Adjust A/P and M/L skill level and platform stability. · Motor Control training: Adjust target skill level and platform stability.

Unweighing System and Gait Trainer 3	· Initiate training based on the patient's self-selected speed determined from the 10 Meter Walk Test performed over ground.
	· Observe and assess gait kinematics, postural control and facilitates in areas needing support.
	· Monitor vital signs and adjust activity based on any signs of distress.
	· The goal is to increase the speed of the Gait Trainer above the patient's comfortable self-selected speed by 0.1-0.2 mph.
	  · The patient must demonstrate optimal gait kinematics and endurance with little compensatory strategies.
	  · Evaluate the patients gait presentation and vary speed and offloading percentage accordingly.
	· Use clinical judgement as to when to adjust the speed based on clinical presentation of the patient.

medBike	· Vitals should be assessed pre and post exercise. · Initial bouts of activity should be limited. · Borg CR10 scale to be used to monitor exertion levels with an optimal level of 4-6. · Use clinical judgement as to when to request increased rpms based on clinical presentation of the patient. · All modes of medBike can be utilized.

Advanced Activities	

Balance System SD	· Random Control training: Adjust target diameter, target speed and platform stability as tolerated.
	· Ball/object toss activity: Position patient on platform facing away from the display.
	· Reaching and functional activities:
	  · Position patient on platform facing away from the display.
	  · Have patient perform reaching activities.
	  · Modify location, weight, size or location of object and platform stability as tolerated.
	· Therapist induced perturbations:
	  · Adjust platform stability to desired level in the Postural Stability training mode.
	  · Induce unexpected perturbations by pushing gently on the patients torso or using their foot to vary the platform.
	  · **Use a spotter or harness support for fall protection at all times during this task.**

Unweighing System and Gait Trainer 3	· Introduce obstacles onto the Gait Trainer belt at slow speed. · Incorporate changes in speed, direction and visual field flow to simulate functional activities. · Set gait speed goals. · Introduce the patient to unsupported ambulation on the Gait Trainer.
medBike	· Vitals to be monitored by clinician. · Borg CR10 scale to be used to monitor exertion levels; maintain levels between 4-6. · Use clinical judgement as to when to request increased rpms based on clinical presentation of the patient. · Recommended duration is 10 minutes with a perceived exertion not to exceed level 4-6. This is based on patient reports and therapist clinical judgement. · All modes of medBike can be utilized.

Sit2Stand Trainer	· Observe and assess isolated muscle activity in conjunction with behavioral responses of the patient. · Facilitate isolated movement patterns. · Borg CR10 scale to be used to monitor exertion levels; maintain levels no greater than level 5.
FreeStep SAS	· Ball Toss, reaching and functional activities to offset patient's dynamic balance. · Incorporate turning activities into gait training to increase stability. · Navigate various surfaces to assist with proprioception levels. · Obstacle courses create a mock functional environment to assist with patients re-entry into the home and the community. · Have the patient perform unilateral lower extremity exercises when harnessed into the FreeStep; providing a safe environment to continue strengthening the involved extremity. · Address developmental sequences to promote scapula, pelvic and core stability using a hi/low table. · Stair climbing for strength, coordination and endurance activities.

Borg CR10 Scale

Scale	Scale Rating	Perceived Exertion	Note
0	Nothing at all		Subjects don't feel any exertion whatsoever, e.g., no muscle fatigue, no breathlessness or difficulties breathing.
0.3			
0.5	Extremely weak	Just noticeable	
0.7			
1	Very weak		Very light. As taking a short walk at your own pace.
1.5			
2	Weak	Light	
2.5			
3	Moderate		Is somewhat, but not especially hard. It feels good and not difficult to go on.
4			
5	Strong	Heavy	The work is hard and tiring, but continuing not terribly difficult. The effort and exertion is about half as intense as "maximal".
6			
7	Very Strong		Is quite strenuous. Subject can go on, but really has to push himself/herself, and are very tired.
8			
9			
10	Extremely Strong	Maximal	An extremely strenuous level. For most subjects this is the most strenuous exertion they have ever experienced.

Biodex Diagnosis Specific Testing and Treatment Guide

Cerebrovascular Accident

A cerebrovascular accident or stroke is the result of a disturbance in the blood supply to the brain. A CVA could occur due to either an ischemic/embolic or hemorrhagic event. Ischemia is due to lack of blood flow and a hemorrhage occurs when there is a rupturing of a vessel. Both types of cerebral vascular incidences, because of the disturbance in the blood supply to the brain may result in a loss of brain function. As a result, the affected area of the brain cannot function normally, which might result in an inability to move one or more limbs on one side of the body, failure to understand or formulate speech, or a vision impairment of one side of the visual field.

CVA BALANCE TRAINING			
Impairment	Effect on Gait	Testing	Treatment
↓ LE muscle strength, distal > proximal	↓ ability to use ankle strategies effectively Increased fall risk=↓ ability to take rapid steps	**Balance System SD**: Postural Stability and Motor Control **Sit2Stand Trainer**: Movement, assessment and observation	**Balance System SD**: Progress as tolerated through the training modes in order of difficulty. Postural Stability or Percent Weight Bearing→ Weight Shift training→Motor Control→Maze Control→Random Control training **Gait Trainer 3:** Gait training with visual feedback for step length, symmetry and speed **Unweighing System w/Gait Trainer 3:** Use Unweighing System for safety during gait activities with vision reduced or altered surfaces **FreeStep SAS**: Walking, multi-plane walking reaching, ball toss, increased velocity stepping and turning in safety harness **medBike**: Active, passive and pedal assist modes to assist with lower extremity strengthening **System 4**: UE neuro attachment for neural and muscular strengthening; ankle and knee strength training for LE **Sit2Stand Trainer**: Resistance training/power training concurrent - alternate days

CVA BALANCE TRAINING (continued)			
Impairment	Effect on Gait	Testing	Treatment
↓ LE proprioception distal > proximal	↓ balance especially when vision is compromised and on compliant surfaces	**Balance System SD**: mCTSIB	**Balance System SD**: Postural Stability training with vision reduced, add head movement and ↓ platform stability or add foam as tolerated **Balance System SD and VibroTactile**: To provide additional somatosensory feedback Suggestions for targeting specific impairments: ↓Proprioception: Decreased vision and + altered surfaces ↓Vision/Perception: +Altered surfaces, incorporate scanning and tracking ↓Vestibular: +Altered surfaces, vision reduced, & head turns **FreeStep SAS**: Over ground walking on unstable surfaces, balance and gait activities with vision reduced

GAIT TRAINING			
Impairment	Effect on Gait	Testing	Treatment
Compromised strength	↓step length ↓ push off ↓ toe clearance ↓ speed	**Gait Trainer 3:** Gait Trainer Summary Report **System 4:** Ankle, knee and hip testing **Sit2Stand Trainer**: Kinesthetic assessment	**Unweighing System w/Gait Trainer 3:** Gait training with visual and auditory feedback for step length, symmetry and speed. Offload patients with Unweighing System up to 40 percent to simulate symmetrical bilateral lower extremity weight bearing patterns, used to for pre-gait activities, step length variability and cadence speed **FreeStep SAS**: :Overground activities with emphasis on specific gait components to address gait deviations **Sit2Stand Trainer**: Resistance training – hip, knee, ankle, core **medBike**: Active, active assistive and passive modes for strengthening

GAIT TRAINING (continued)			
Impairment	Effect on Gait	Testing	Treatment
Decreased Proprioception	Base of support ↑ double support time ↓ walking ability when vision reduced	**Gait Trainer 3:** Gait Trainer Summary Report	**Balance System SD and VibroTactile**: To provide additional somatosensory feedback. Suggestions for targeting specific impairments: ↓Proprioception: Decreased vision and + altered surfaces ↓Vision/Perception: +Altered surfaces, incorporate scanning and tracking ↓Vestibular: +Altered surfaces, vision reduced, & head turns **Gait Trainer 3**: Gait training with visual feedback for step length, symmetry and speed **Unweighing System w/Gait Trainer 3:** Use Unweighing System for safety during gait activities with vision reduced or altered surfaces **FreeStep SAS:** Over ground walking on unstable surfaces and gait activities with vision reduced
Compromised Endurance	↓ walking distance and community ambulation Decreased gait speed	**Gait Trainer 3**: 2- or 6-minute walk test	**Gait Trainer 3**: Increase time and speed while maintaining appropriate cardiovascular training parameters **BioStep 2**: Build whole body endurance and/or use for patients not appropriate for treadmill training **Sit2Stand Trainer**: Endurance training/power training to assist with improving gait tolerance and improved tolerance for functional activities **medBike**: Active, active assistive and passive modes for strengthening

9. Terminology

- Cerebral Vascular Accident
- Rehabilitative Care Plan
- Remediation
- Compensatory
- Direct Interventions
- Technology Assisted Interventions
- Impairment
- Disability
- Level of Neurological Impairment
- Postural Control
- Postural Stability
- Synergies
- Isolated movement patterns
- Activities of Daily Living (ADLs)

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