*"The Clinical Advantage"*™

# Peripheral Neuropathy

## A Clinical Guideline for the Treatment of Patients with Peripheral Neuropathy using Biodex Balance SD, BioStep, Gait Trainer and Unweighing System.


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BIODEX
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Natalie Thompson is a 1992 graduate of SUNY at Stony Brook. She holds a dual degree in Biology and Physical Therapy. She has a background in clinical, managerial and educational settings. Natalie has practiced for 10 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. She 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 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 is an experienced Occupational Therapist who has worked in the field for 16 years. David started his OT 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. Today David not only continues to treat patients in the rehabilitative setting, but has expanded his role to student supervisor, guest lecturer and adjunct professor with specific focus on neuroscience and cognition. Since 2010, David has used his advanced clinical knowledge as a consultant for Biodex Medical Systems, Inc., training therapists on the use of the Unweighing System, Gait Trainer, and Balance System SD from a logistical and clinical perspective. He has also developed and taught advanced training courses on these three products.

### Kurt Jackson PT, PhD, GCS

Kurt is the neurology coordinator at the University of Dayton's Doctor of Physical Therapy Program. He has published numerous scientific studies on balance and gait in individuals with neurological disorders. He has also written several book chapters on the role of exercise in the management of chronic neurological disorders. He has also 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

Biodex Medical Systems, Inc. has been providing innovative medical devices and service excellence for more than 60 years. We're especially proud of this accomplishment and earned it the old-fashioned way – by putting our customers and employees first. It all begins with our belief in science-based solutions.

At Biodex, over 200 employees strive to keep our customers at the forefront of the art and science of medicine.  It's no wonder so many world-class facilities call Biodex first.

Within this guide you will find an overview of the signs and symptoms common to Peripheral Neuropathy along with recommended treatment strategies.  Online eLearning courses are available on the Biodex website in support of this educational resource.
www.biodex.com/elearning.

A Diagnosis Specific Testing and Treatment Guide, located in the back of this document, is intended to provide treatment strategies at a glance, directly related to specific impairments.

# 2. Purpose

This Clinical Resource Guideline is intended to be used as a guide and not to supersede clinical judgment or a therapist's decision-making process. The role of the Guideline is to improve patient outcomes as well as increase overall department efficiency.

By incorporating traditional examination/evaluation techniques with today's level of technology, Biodex products will assist in maximizing therapist time management and effectiveness. The utilization of standardized, objective testing/training devices can make treatments easily reproducible. The above, combined with integrating research, will assist with the creation of an evidence-based productive practice where tradition and technology meet.

# 3. Overview of Peripheral Neuropathy

Peripheral neuropathy occurs due to damage to the peripheral nervous system. These are the nerves which travel distally from the spinal cord and transmit information from the brain and spinal cord (the central nervous system) to every other part of the body. (See Figure 1). Peripheral nerves also send sensory information back to the brain and spinal cord, such as a message that the feet or hands are cold. When the peripheral nervous system suffers from damage, the messages between brain and body are sometimes distorted or interrupted.

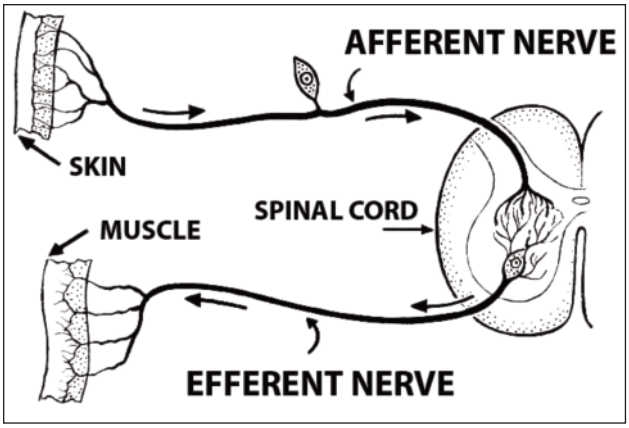



*Figure 1*

Every peripheral nerve has a highly specialized function in a specific part of the body. Therefore, the result of peripheral damage presents with a wide array of symptoms. The various symptoms that may present are numbness, tingling, sensitivity to touch, muscle weakness and balance loss. Some people lose their sensation and report that they feel as if they are wearing gloves or stockings. Position sense, vibratory sense and multiple-point discrimination ability can also be diminished or even lost. In severe cases, symptoms may present as burning sensations, muscle wasting, muscle weakness or even paralysis.

Peripheral neuropathy can occur suddenly, progress rapidly and then resolve, as in Guillain-Barré syndrome. In other forms of peripheral neuropathy, called chronic types, symptoms begin subtly and progress insidiously. Some people may experience exacerbation and remission, have periods of relief and then relapse. Very few forms prove fatal unless complicated by other diseases and health impairments.

## Conditions

Peripheral neuropathy may be either acquired or inherited. Causes of acquired peripheral neuropathy include physical injury (trauma) to a nerve, tumors, toxins, autoimmune responses, nutritional deficiencies, alcoholism, and vascular and metabolic disorders.

### Acquired Neuropathy

Physical injury (trauma) is the most common cause of injury to a nerve. Injury or sudden trauma, such as from automobile accidents, falls, and sports-related activities, can cause nerves to be partially or completely severed, crushed, compressed, or stretched, sometimes so forcefully that they are partially or completely detached from the spinal cord. Less dramatic traumas can also cause serious nerve damage. Broken or dislocated bones can exert damaging pressure on neighboring nerves, and slipped disks between vertebrae can compress nerve fibers where they emerge from the spinal cord.

Systemic diseases, hormonal imbalances, vitamin deficiencies, kidney involvement, infections and autoimmune disorders affect the entire body and often cause peripheral neuropathy. These disorders may include: metabolic and endocrine disorders. Diabetes mellitus is a leading cause of peripheral neuropathy in the United States.

Some neuropathies are caused by inflammation resulting from immune system activities rather than from direct damage by infectious organisms. These are autoimmune diseases and typically are neuropathies that can develop quickly or slowly. They can be chronic forms or exhibit a pattern of alternating remission and relapse. Acute inflammatory demyelinating neuropathy, better known as Guillain-Barré syndrome, can damage motor, sensory, and autonomic nerve fibers. Most people recover from this syndrome although severe cases can be life threatening.

Toxins can also cause peripheral nerve damage. People who are exposed to heavy metals (such as arsenic, lead, mercury, and thallium), industrial drugs, or environmental toxins frequently develop neuropathy. Certain anticancer drugs, anticonvulsants, antiviral agents, and antibiotics have side effects that can include peripheral nerve damage, thus limiting their long-term use.

**Inherited Neuropathy**

Inherited forms of peripheral neuropathy are caused by changes in the genetic code or by genetic mutations. Some genetic errors lead to mild neuropathies with symptoms that begin in early adulthood and result in little, if any, significant impairment. More severe hereditary neuropathies often appear in infancy or childhood.

## Tests for Peripheral Neuropathy

Diagnosing peripheral neuropathy is often difficult because the symptoms are highly variable. A thorough physical exam, patient history, neurological exam and any previous screening/testing, and other additional tests may be ordered to help determine the cause and extent of the nerve involvement. Peripheral neuropathy is a lower motor neuron impairment.

Electromyography (EMG) involves inserting a fine needle into a muscle to compare the amount of electrical activity present when muscles are at rest and when they contract. EMG tests can help differentiate between muscle and nerve disorders. Nerve conduction velocity (NCV) tests can precisely measure the degree of damage in larger nerve fibers, revealing whether symptoms are being caused by degeneration of the myelin sheath or the axon.

No medical treatments currently exist that can cure inherited peripheral neuropathy. However, there are therapies for many other forms. In general, adopting healthy habits such as maintaining optimal weight, avoiding exposure to toxins, following a physician-supervised exercise program, eating a balanced diet, correcting vitamin deficiencies, and limiting or avoiding alcohol consumption can reduce the physical and emotional effects of peripheral neuropathy.

## Physical Therapy

Active and passive forms of exercise can reduce spasms, improve muscle strength, and prevent muscle wasting in paralyzed limbs. Losing sensation and strength in the extremities can create balance issues and present as a fall risk. As a result of muscular weakness, decreased range of motion and compromised balance, the patient may present with poor endurance.

Mechanical aids can help reduce pain and lessen the impact of physical disability. Hand or foot braces can compensate for muscle weakness or alleviate nerve compression. Orthopedic shoes can improve gait disturbances and help prevent foot injuries in people with a loss of pain sensation.

### In the Clinic

Peripheral neuropathy clinically presents with physical signs of neurological dysfunction such as weakness or sensory loss, decreased strength and balance. Muscle contractions produce the force required for postural responses and locomotion. When a muscle contraction is interrupted due to peripheral compromise, even posture can be affected. A chain reaction then occurs; gait, balance, mobility and function are directly influenced. In general, neuropathy will create specific impairments with resultant clinical presentations, although every client will present uniquely. The basic overall impairments, observable clinical impression and characteristics of a neuropathic gait are listed in Figure 2.

**Impairments**

| IMPAIRMENTS | CLINICAL IMPRESSION |
|---|---|
| **Decreased LE /Muscle Strength** | Unilateral/bilateral genu recurvatum<br>Foot drop/foot slap<br>High steppage gait |
| **Decreased Proprioception** | Wide base of support |
| **Decreased Endurance** | Slow gait speed |
| **Range of Motion Deficits** | Foot drop |
| **Sensory Deficits** | Poor weight bearing in lower extremities |
| **Decreased Balance** | Ataxia<br>Stumbling/falls<br>Wide base of support |
| **Gait Abnormalities** | Stance phase asymmetrical<br>Shortened step and stride length<br>Slow gait speed<br>Minimal or absent arm swing |
| **Postural Changes** | Lateral trunk lean R/L<br>Kyphosis<br>Asymmetry in midsagittal planes |

*Figure 2*

**Function**
The optimal physical therapy goal is to maximize an individual's functional abilities and return them to their highest level of independence.

A break in the mobility chain due to an acquired illness can affect all components of mobility including strength, balance, proprioception, ambulation status, endurance and range of motion. Remediation versus a compensatory approach will best maximize the ability to improve activity and return the participation in all functional activities.

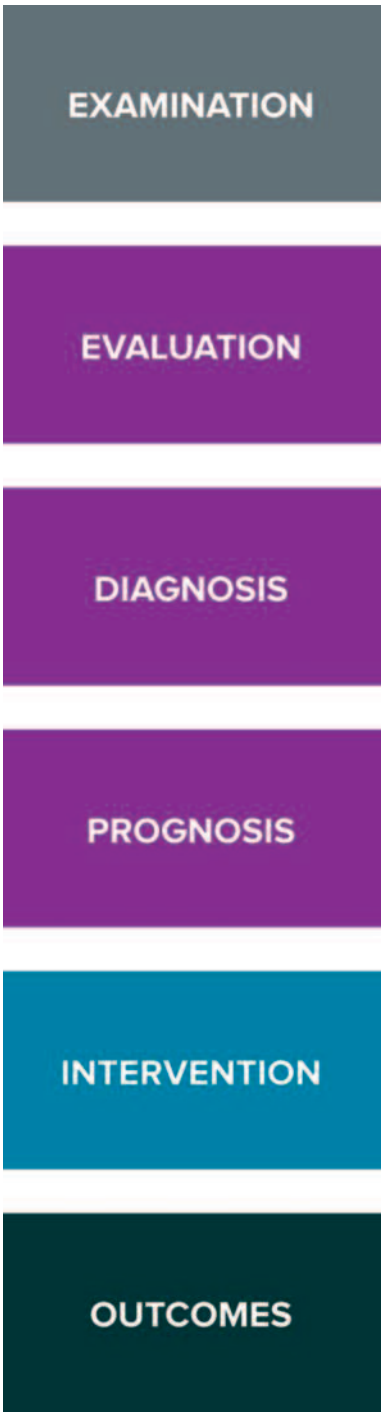
## Conclusion

Following the completion of this Clinical Resource Guideline on Peripheral Neuropathy the anticipated learning outcomes are as follows:

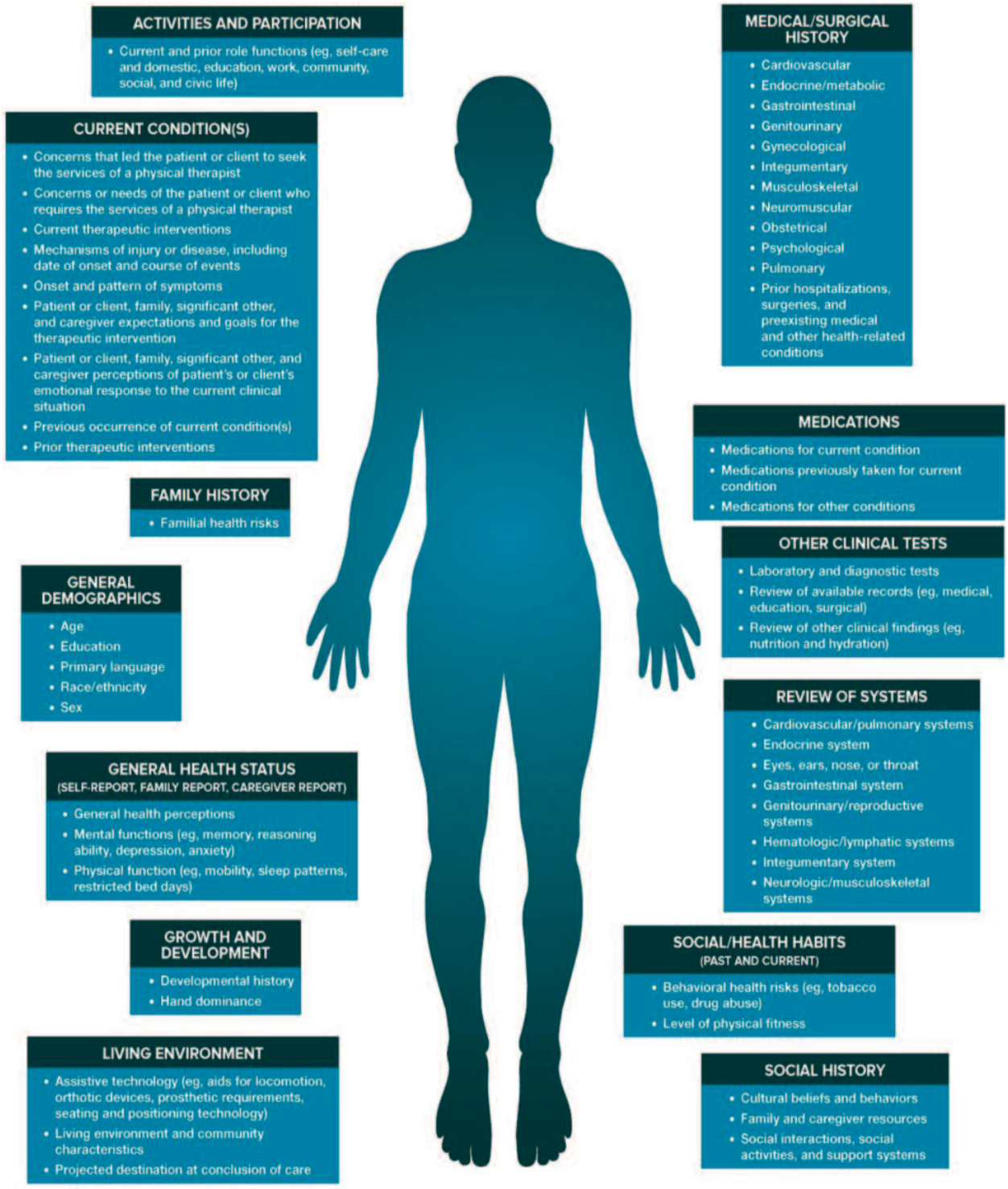
- Demonstrate a commitment to personal and professional growth with valid and reliable information.
- Guide healthcare professionals in the clinical decision-making process for developing a plan of care and intervention strategy when utilizing isokinetic equipment.
- Communicate clear and concise guidelines to assist in the education of therapists and healthcare professionals.
- Assist in guiding healthcare providers to function as independent problem solvers in the practice environment relating to neurologic impairment and training on isokinetic equipment.
- Supplement the theoretical learning of physical therapy pertinent to isokinetic 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 healthcare practices.

# 4. Initial Patient Interaction

**Elements of the Patient/Client Management Model.**



**Types of data that may be generated from a patient or client history.**



## Examination

A clinical examination should take place for all patients. It is a screening procedure as well as a means for data collection after reviewing all the body systems. A patient's history is obtained through an interview and review of the patient's record. It includes a social history, employment, work status, living environment and general health status. The data collected from the patient's history provides information which will allow for a hypothesis about the existence and origin of their impairments and functional limitation. The examination should also include a hands-on component with a systems review consisting of cardiovascular health including heart rate, respiratory rate and blood pressure. During the examination of the integumentary system the pliability, integrity, color and texture of the skin should be assessed. During the muscle system review a gross motor assessment should be performed and should include, but not limited to, range of motion and strength. When screening the neuromuscular system coordination, balance, gait, transfers, tone, motor control and motor learning should be screened.

Data should be collected from the comprehensive identification of the patient's history and systems review. This information helps form a diagnostic hypothesis and assists the clinician in determining the needs of the patient. From there, the therapist will be able to select specific tests and measures. Tests and measures are paramount in ruling out causes of impairments and functional limitations. This will determine the diagnosis and prognosis, after which a plan of care can be established.

## Evaluation

Physical therapists perform evaluations (clinical judgment) based on the data gathered from the examination. All findings from the history, systems review, and tests and measures assist in establishing the diagnosis, prognosis and plan of care. Factors that influence the type of evaluation performed include the clinical findings, the extent of function loss, social considerations, overall physical function and health status. The findings of the evaluation also reflect how the physical therapist will consider the severity and complexity of the current impairments, functional limitation, disability, the living environment, potential discharge destinations, and social support.

## Diagnosis

A diagnosis can be one consisting of a medically-based description or be inclusive of a complex and dimensional description of the patient based on information from the cellular level to the highest level of functioning. Physical therapists use labels to help identify the impact of a condition on function and mobility.

## Prognosis

Once the specific findings for a diagnosis have been collected a prognosis can be determined. The details gathered from the patient history, evaluation process and testing will assist in formulating the prognosis. A prognosis is the predicted level of improvement and gain in function for the patient following treatment. When documenting the prognosis, the amount of time it takes for specific functions to occur should be specified. In order to achieve the prognosis, a plan of care must be established. The plan of care includes goals and the intervention plan which will assist in achievement of the goals. Changes in impairments, functional limitations, disabilities and the changes in health wellness and fitness needs are expected to occur as the result of implementing the plan of care. The anticipated goals and expected outcomes in the plan should be measurable and time limited.

## Intervention

The intervention is the plan of care designed to improve, enhance and maximize function. The intervention is the purposeful interaction of the physical therapist with the patient. Various physical therapy procedures and techniques are used to produce changes in the condition that are consistent with the diagnosis and prognosis. Decisions about interventions are based on the timely monitoring of the patient's response and progression levels made towards achieving goals.

## Outcomes

Outcomes are the actual results of the plan of care that indicate the impact on functioning. Outcome measures directed toward activity and participation demonstrate the value of physical therapy in helping individuals achieve their identified goals. As the individual progresses through their rehab plan the physical therapist repeatedly will measure the outcomes of the services provided by characterizing or quantifying the impact the intervention had on any or all of the following domains:

- Pathology or health condition
- Impairments in body functions and structures
- Activity limitations
- Participation restrictions
- Risk reduction/prevention
- Health, wellness, and fitness
- Societal resources
- Patient or client satisfaction

## Selecting Outcome Tools

The physical therapist selects the appropriate standardized outcome measures to quantify the individual's status initially and during the patient's rehab plan as well as just prior to discharge. The therapist might choose self-report or performance-based tools, or general or specific measures. It is important to use outcome measures pertinent to each specific patient.

## Establishing a Baseline and Outcome Status

The use of standardized tests and measures early in the episode of care establishes the baseline status of the individual, providing a means to quantify change in functioning. Beginning with the history, the physical therapist identifies the individual's expectations, perceived need for physical therapist services, personal goals, and desired outcome status. The physical therapist then considers whether the desired goals and outcome status are realistic in the context of the examination data and the resulting evaluation, which includes determining the diagnosis.

Based on this information and the health condition causing the impairments effecting a patient's functions and structures, activity limitations, and participation restrictions, the physical therapist then generates a prognosis intended to predict likely outcomes.

Prior to concluding the episode of care, the physical therapist measures the individual's outcomes. Outcomes identify change in functioning. Based on the results of outcome measurement, the physical therapist determines the outcome status of the patient and whether the goals have been met. The physical therapist documents the individual's status and the rationale for conclusion of care.

Physical therapists gather outcome measurements not only to determine the success of intervention, but also to obtain information about the individual's perspective on progress. Outcome measures can also be used in research to yield reliability and validity of treatment techniques and strategies.

# 5. Patient Balance and Mobility Classification

## Balance Levels

**Beginner - Postural Stability and Symmetry**

Beginner activities focus on maintaining good static alignment and symmetry under a variety of environmental and sensory conditions. For each of the activities listed below, you may use either the Postural Stability or Percent Weight Bearing training modes on the Balance System SD. Your choice of training modes will depend on the impairments of the patient and the therapists' goals. For example, a patient with peripheral neuropathy who is showing difficulty with standing on their involved leg may benefit from the Percent Weight Bearing mode of training. The following is a list of the sensory and environmental conditions that can be altered individually or in combination to provide the optimal level of challenge to your patient.

- **Base of Support Modifications** – Alter foot position including wide, narrow, semi-tandem, tandem and single-leg.
- **Surface Platform Modifications** – Alter platform stability level (0-12), add foam.
- **Vision Modifications** – Eyes open (EO), reduced or altered vision (glasses with scotch tape, distracting pattern), Eyes closed (EC).
- **Head Movements** – Vertical, horizontal, diagonal. Alter amplitude and speed as tolerated.
- **Dual-Task Activities** – Add increasing cognitive demand (e.g. backward counting, answering questions).

**Intermediate - Dynamic Weight Shifting**

Intermediate balance activities require the client to perform voluntary weight shifting activities. Using the Weight Shift training mode, the client can focus on simple anterior/posterior and medial/lateral weight shifts with visual feedback. The Limits of Stability training mode can be used to challenge both A/P and M/L weight shifts as well as diagonal weight shifts. Maze Control requires even greater control of weight shifting. Additionally, the Balance System SD can be used during numerous functional tasks that incorporate dynamic weight shifting. The following training modes and activities are listed in approximate order of difficulty. Within each training mode or activity, difficulty level can be further adjusted by altering the parameters indicated.

- **Weight-Shift training** - Adjust A/P and M/L skill level and platform stability
- **Limits of Stability training** - Adjust target skill level and platform stability
- **Maze Control training** - Adjust maze skill level and platform stability
- **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.

**Advanced - Reactive Postural Control Training**

Advanced balance activities require the client to respond to unplanned or unanticipated challenges to balance. This type of balance control is essential for reducing fall risk during unintended loss of balance such as during a slip or trip.

- **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. Adjust platform stability to desired level in the Postural Stability Training mode. Toss ball or other object altering speed and direction as tolerated in random directions. Use spotter or harness support for fall protection at all times during this task.
- **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 push on the platform. Use spotter or harness support for fall protection at all times during this task.

## Mobility Levels.

| CATEGORY | PATIENT CHARACTERISTICS |
|---|---|
| **Level 1** | Unable to stand or ambulate |
| **Level 2** | Stands for < 2 min with UE support and significant physical assistance |
| **Level 3** | Stands for 2-5 min with UE support and /or minimal physical assistance. May ambulate short distance with an assistive device and physical assistance |
| **Level 4** | Stands greater than 5 minutes with limited to no UE support and no physical assistance. Likely ambulates with the use of an assistive device an no greater than contact guard assistance |
| **Level 5** | Stands greater than 5 minutes without UE support or physical assistance. Likely ambulates without assistive device with no greater than supervision level |

# 6. Testing/Training

## Application of the Biodex Balance System SD for Patients with Peripheral Neuropathy based on Patient Mobility Classification

The following Clinical Resource Guide is designed to provide basic information for choosing tests and treatments when using the Balance System SD. It is not intended to be used as a protocol or to replace your clinical judgment.

**Balance Testing**

Several factors are most likely to influence what test(s) you will choose for your patient. One is the functional level of your patient and the other is the patient's diagnosis/impairments. The following tables show common test and training choices based on functional levels and diagnosis/impairments as described below. You will generally use a combination of both functional level and diagnosis to select the appropriate test(s) for your patient. As a general rule, if time and patient tolerance allows, perform at least one test for static standing (Postural Stability Test) and a dynamic test mCTSIB, Fall Risk Test or Limits of Stability test.

| PATIENT MOBILITY LEVEL | BALANCE TESTING | BALANCE SYSTEM SD TESTS |
|---|---|---|
| **Level 1** | N/A | Patient unable to stand not appropriate for Balance System SD testing. |
| **Level 2** | Postural Stability Test | Use Static Platform setting. Due to poor endurance increase rest time between trials and duration. May need elevated mat or raised chair due to weakness and poor standing tolerance. |
| **Level 3** | Postural Stability Test<br>mCTSIB Test | Patient may not be able to tolerate all three tests in single testing session due to poor standing tolerance. May need assistance of raised chair or elevating mat to position patient to stand. Begin with Postural Stability and if tolerated perform mCTSIB. |
| **Level 4** | mCTSIB<br>Limits of Stability<br>Fall Risk Test | Patient may require rests between each test but would likely be able to complete two to three in a single test session. Adjust stability of platform as per patient tolerance. Determine testing based on patient's endurance and tolerance to testing. |
| **Level 5** | Postural Stability Test<br>mCTSIB<br>Limits of Stability<br>Fall Risk Test | Adjust platform stability to patient tolerance. Patient would likely tolerate two or more of these tests. |

**Balance Training**

Similar to testing, choosing the appropriate training activities will depend on both the functional level of your patient and their specific diagnosis/impairments. Use the tables below to help select appropriate training activities. On pages 5-1 to 5-2 you will find a description of the Balance System SD training activities organized into three different levels that are referred to in the tables below.

| PATIENT LEVEL | BALANCE TRAINING | BALANCE SYSTEM SD TRAINING[b] |
|---|---|---|
| **Level 1** | N/A | May not be appropriate for Balance System SD training. May tolerate with harness support and combined use of Unweighing System |
| **Level 2** | Postural Stability<br>Percent Weight Bearing<br>Weight Shifting | Initiate beginner[a/b] level balance activities progressing as tolerated generally starting with static platform settings. |
| **Level 3** | Postural Stability<br>Weight Shifting<br>Percent Weight Bearing<br>Limits of Stability Training | Incorporate both beginner and intermediate[b] level balance activities. Decrease stability level of platform as tolerated. |
| **Level 4** | Postural Stability<br>Limits of Stability Training<br>Maze Control | May tolerate beginner through advanced[b] level balance activities. Increase difficulty level and time as tolerated. |
| **Level 5** | Postural Stability<br>Limits of Stability Training<br>Maze Control<br>Random Control | Will likely focus on intermediate and advanced[b] level balance activities. |

[a] *For beginner level patients, placing the Balance System SD next to an elevating mat table may be helpful for getting patient on and off unit.*

[b] *Refer to detailed description of balance levels on page 5-1.*

# 7. Clinical Forms

## Balance System SD Activity Tracking Form

Patient:_____ Date:_____

| **Beginner Training Activities: Postural Stability and Symmetry**<br>**Mobility Levels 2-3**<br>PSTR = Postural Stability Training Mode WSTR = Weight Shift Training Mode | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Exercise #** | **SD Training Mode**<br>PSTR or WSTR | **Vision**<br>Open<br>Reduced<br>Closed<br>Conflicting | **Task**<br>None, Head Turns, Cognitive/Dual Task | **Platform**<br>Stability Level (1-12) | **Stance**<br>Norm, Narrow, Semi-Tandem, Tandem, Single Leg | **Time** | **Reps** |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

| **Intermediate Training Activities: Dynamic Weight Shifting**<br>**Mobility Levels 3-4**<br>PSTR = Postural Stability Training Mode, WSTR = Weight Shift Training Mode, LOS = Limits of Stability | | | | | |
|---|---|---|---|---|---|
| **Exercise #** | **SD Training Mode**<br>PSTR, WS, LOS, Maze, Random or other activity (describe) | **Skill Level**<br>(1-3) | **Stability Level**<br>(1-12) | **Time** | **Reps** |
| | | | | | |
| | | | | | |
| | | | | | |

| **Advanced Training Activities: Reactive Postural Control**<br>**Mobility Levels 4-5** | | | | |
|---|---|---|---|---|
| **Exercise #** | **Activity**<br>Random Control Training, Ball toss, Therapist induced perturbations | **Stability Level**<br>(1-12) | **Time** | **Reps** |
| | Describe: | | | |
| | Describe: | | | |
| | Describe: | | | |

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# Diagnosis Specific Testing and Treatment Guide

## Peripheral Neuropathy

Introduction: Peripheral neuropathy is a neurological disorder that involves damage or disease of the peripheral nervous system. Diabetes is one of the most common causes of neuropathy, while another large percentage of cases are idiopathic in nature. Balance and gait deficits are common in peripheral neuropathy and play a major role for increasing fall risk. The following tables identify how Biodex products can be used in the comprehensive management of balance and gait disorders for individuals with peripheral neuropathy. For more detailed information on the use of Biodex medical devices for testing and treatment, visit www.biodex.com/physmed.

| BALANCE | | | |
|---|---|---|---|
| **IMPAIRMENT** | **EFFECT ON BALANCE** | **TESTING** | **TREATMENT** |
| ↓LE muscle strength, distal > proximal | ↓ability to use ankle strategies effectively<br>↓ weight shift ability<br>↓ability to take rapid steps. | **Balance System SD:** Postural Stability or Fall Risk Test and Limits of Stability<br>**BioSway:** Postural Stability and Limits of Stability | **Balance System SD / BioSway:** Progress as tolerated through the training modes in order of difficulty: Postural Stability or Percent Weight Bearing →Weight Shift Training→Limits of Stability→Maze Control→Random Control Training<br>FreeStep SAS: Reaching, Ball toss, rapid stepping and turning in safety harness<br>System 4 Pro: Ankle and knee strength training |
| ↓LE proprioception distal > proximal | ↓balance especially when vision is compromised and on compliant surfaces | **Balance System SD:** m-CTSIB<br>**BioSway:** m-CTSIB | **Balance System SD / BioSway:** Postural Stability Training with vision reduced, add head movement and ↓ platform stability or add foam as tolerated<br>**FreeStep SAS:** Over ground walking on unstable surfaces, balance and gait activities with vision reduced |

| GAIT | | | |
|---|---|---|---|
| **IMPAIRMENT** | **EFFECT ON GAIT** | **TESTING** | **TREATMENT** |
| ↓LE muscle strength, > proximal | ↓step length<br>↓step symmetry<br>↓ push-off<br>↓ toe-clearance<br>↓ speed | **Gait Trainer 3 / RTM600 Treadmill:** Gait Trainer Summary Report<br>**System 4 Pro:** Ankle and knee testing | **Gait Trainer 3 / RTM600 Treadmill:** Gait distal training with visual and auditory feedback for step length, symmetry and speed<br>**System 4 Pro:** Ankle and knee strength training |
| ↓LE proprioception distal > proximal | ↑ base of support<br>↑ double support time<br>↓ walking ability when vision reduced | **Gait Trainer 3 / RTM600 Treadmill:** Gait Trainer Summary Report | **Gait Trainer 3 / RTM600 Treadmill:** Gait training with visual feedback for step length, symmetry and speed.<br>**Unweighting System w/Treadmill** – Use Unweighting System for safety during gait activities with vision reduced or altered surfaces.<br>**FreeStep SAS:** Over ground walking on unstable surfaces and gait activities with vision reduced. |
| ↓ endurance secondary to de-conditioning | ↓ walking distance and community ambulation. | **Gait Trainer 3 / RTM600 Treadmill:** 2 or 6 minute walk test | **Gait Trainer 3 / RTM600 Treadmill:** Increase time and speed while maintaining appropriate cardiovascular training parameters.<br>**BioStep Semi-Recumbent Elliptical:** Build whole body endurance and/or use for patients not appropriate for treadmill training. |

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