THE ROLE OF THE PHYSICAL THERAPIST IN THE EVALUATION AND TREATMENT OF CHILDREN WITH CEREBRAL PALSY

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TREATMENT OF CEREBRAL PALSY

APPROVAL SHEET

This case report is submitted in partial fulfillment of
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The final copy of this case study has been examined by the signatories, and we find that both the content and the form meet acceptable presentation standards of scholarly work in the above mentioned discipline.
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ABSTRACT

Introduction  Cerebral palsy (CP) affects more children than any other physical disability. Despite the vast research pertaining to cerebral palsy, little is known regarding superior or optimal treatment options for this population. Previously, therapists have been instructed that strength training this population would cause an increase in spasticity but recent literature proves that children with CP can make gains in strength without decreasing their available range of motion. Purpose By completing this literature review and case report, extensive knowledge has been gained pertaining to the most effective treatment choices for children with CP. Background Information CP designates a group of permanent disorders of movement that is caused by non-progressive disturbances in the fetal or infant brain. There are many different classifications of CP and each child must be treated based on their individual impairments. The focus of this study was on spastic CP as approximately 80% of children with CP will present with spastic features. Evaluative Analysis Physical therapists must perform an extensive evaluation of children with CP including an evaluation of posture, tone, strength, range of motion, balance, gait, and overall functional mobility. Treatment There are a variety of treatment options for children with CP and this study intended to identify the most beneficial strength training parameters for this population. Children with CP benefit from the same exercise principles as typically developing peers including, specificity of training, adaptation, overload, and progression. Case Report An 8-week case report was completed focusing on the outpatient physical therapy management of an 11-year-old male with spastic CP. Summary Physical therapists play an essential role in the treatment of children with CP and it is important to address the individual needs of each
child. Physical therapy should incorporate strength training, aerobic training, stretching, along with other interventions focusing on the motor impairments involved with CP.
INTRODUCTION

Cerebral Palsy (CP) is a neurological disorder that is characterized by variable deficits, with the hallmark characteristic being motor impairment.\textsuperscript{1} CP is the most common physical disability affecting children.\textsuperscript{2} Children with CP show decreased activity and participation when compared to non-disabled children, and this can lead to a decreased quality of life and low self-esteem.\textsuperscript{3} Research on the frequency, duration, and intensity of exercise for children with CP is increasing, but to date there are no evidence-based standards on optimal treatment options for physical therapy interventions. When a physical therapist considers treatment options for a patient with CP, there are a wide variety of appropriate choices with each plan of care individualized to the patient. In best practice, the therapist will also address the family or caregiver’s desires while determining realistic outcomes for the patient. There is increasing evidence indicating that children with CP benefit from strength training as well as aerobic training, but research is still lacking with regard to proper frequency, intensity, timing, and progression.\textsuperscript{4-6} It is critical that the physical therapy interventions produce measureable functional gains that are meaningful to the individual and caregivers.\textsuperscript{7}

PURPOSE

The purpose of this evidence review and case report is to investigate the different approaches to physical therapy treatment for children with CP with a focus on strength training. Through this investigation of strengthening and conditioning a focus will be on upper motor deficits and exercises that target related weakness. Results from this investigation may assist physical therapists in developing an intervention plan to include frequency, duration, and intensity of strengthening in children with CP.
BACKGROUND INFORMATION

Cerebral Palsy designates a group of permanent disorders of movement and posture that are attributed to non-progressive disturbances occurring in the developing fetal or infant brain. CP is the leading cause of physical disability in childhood in the United States and affects the social, physical, emotional, and financial well-being of the individuals and families affected by it. As a result of the advances in obstetric and neonatal care, there has been a significant upward trend in the prevalence of low birth weight infants, with some infants suffering from neurological deficits. Despite the advances in medicine, the reported prevalence of CP has remained stable, impacting an estimated 2.3 to 3.6 of every 1000 live births in the United States. United Cerebral Palsy estimates that each year 9,000 infants and pre-kindergarten age children are diagnosed with CP and that there are approximately 770,000 children and adults with CP living in the United States.

There is no known single cause of CP, but researchers believed to have discovered many linked factors. The development of the prenatal brain is very complex and is susceptible to errors resulting in varying degrees of abnormalities and presentations. Any disease process that has an effect on the developing or infant brain may cause cerebral palsy. Teratogens and any other substances that increase the risk for premature delivery and low birth weight, such as alcohol and tobacco might indirectly increase the risk for CP. Since the fetus receives all of its nutrients and oxygen from blood that circulates through the placenta, any condition that affects the placenta may increase the risk of premature delivery, and therefore the chances of CP occurring. Inflammation of the placenta occurs in 50 to 80% of premature births. Pregnant women
who suffer poor nutrition, inadequate prenatal care, or who suffer diabetes, all have an increased chance of delivering prematurely. Serious physical trauma, including abuse or a fall, to the mother during pregnancy can cause serious injuries to the developing brain of the fetus. Several maternal-fetal infections are known to increase the risk for CP, including rubella, cytomegalovirus and toxoplasmosis. A fetal cerebrovascular accident can also increase the risk for CP. Until recently, intra-ventricular hemorrhage was the most common form of brain injury in the premature infant. Presently, pre-ventricular white matter injury has become the most common cause of brain damage. Rh incompatibility can cause kernicterus in the newborn. Kernicterus is a syndrome characterized by CP, high frequency hearing loss, visual problems, and discoloration of the teeth.

CP is significantly more common in preterm and low-birth weight infants, and half of all cases occur in infants with weight of less than a kilogram at birth. The premature infant between 23 and 32 weeks’ gestation is at the highest risk of periventricular injury. During delivery, anything that causes birth asphyxia such as, an umbilical cord around the neck or placenta previa, will reduce the amount of blood and oxygen that the infant brain is receiving and can result in CP. Prolonged or difficult labor because of a breech presentation can also contribute to asphyxia. Genetic syndromes, chromosome abnormalities, and brain malformations may contribute to cerebral palsy as well.

If insult is not caused prenatally or peri-natally, it is possible that it can be caused post-natally. About, 20% of incidence of CP are caused post-natally resulting from bacterial meningitis, pediatric stroke, viral encephalitis, hyperbilirubinemia, or child
abuse. Physical trauma to an infant resulting in traumatic brain injury, such as from abuse, accidents, or near drowning/suffocation, or lead exposure could also possibly cause CP. If the brain damage occurred after birth, up to 3 years of age, the CP is considered to be acquired CP.

The most important risk factors to recognize when screening for CP are prematurity and low birth weight. In the United States, 1 out of 8 infants are born before 37 weeks of gestation. Beside being put at risk for CP, being born prematurely puts the infant at risk for various learning disabilities with 50% of premature infants requiring some form of special education. A baby who is born prematurely and who weighs less than 1500 grams (3.3 lbs) has a 25 to 31 times greater risk of developing CP than a typically sized newborn who weighs 3500 grams (7.7 lbs). Of infants that weight less than 2500 grams, one third of them will develop CP. In approximately 40% of children diagnosed with CP, the cause cannot be identified.

When diagnosing CP the most common observations are delayed motor development, abnormal muscle tone, and unusual and decreased postural control. Specific laboratory tests, cerebral imaging using CT scans, MRI’s, and ultrasound can all be used as diagnostic tools for CP. Electroencephalography is indicated when seizures are present or suspected. Early and accurate identification of CP provides the most likely opportunity for facilitation of optimal motor development. A physician will make the official diagnosis of Cerebral palsy, but a child may be referred to a physical therapist for further evaluation of their motor development and appropriate treatment.
TYPICAL IMPAIRMENTS

The manifestations of CP vary widely among individuals and are dependent upon the magnitude, extent, and location of the brain lesion. Children with CP typically present with primary and secondary impairments of body function and structure. Primary impairments are impairments that are apparent when the child is diagnosed with CP and are directly caused by the brain damage that occurred. Secondary impairments tend to arise over time, and are often the result of primary impairments. Common primary impairments for children with CP include alterations in muscle tone, motor coordination, and postural stability. Secondary impairments that may arise due to these primary impairments include decreases in range of motion, decreased forced production, and decreased endurance. Children with CP often demonstrate movement disorders, spasticity, muscle weakness, and ataxia. Movement disorders are frequently accompanied by other disturbances in sensation, cognition, communication, perception and/or behavior. CP can be classified in many different ways. Classifications of cerebral palsy are based on: deformity or abnormality (spastic, dyskinetic, ataxia, or mixed), the distribution of the symptoms (hemiplegia, monoplegia, diplegia, or quadraplegia) or location of CNS injury (periventricular, brainstem, cortical, pyramidal, or extrapyramidal).

Cerebral palsy is one disorder that causes damages to the upper motor neurons (UMN) of the central nervous system. As an UMN disorder, CP gives rise to both positive and negative symptoms. Positive symptoms associated with CP include muscle over-activity, increased firing of agonists and antagonist muscle group, and increased flexor reflexes, while the negative symptoms include weakness and loss of coordination
and dexterity. With UMN damage, muscles that are supplied by motor nuclei below the level of the lesion are affected in synergistic groups. Contralateral limbs will be affected when the lesion is above the decussation line in the pyramids, and ipsilateral muscles will be affected if the damage is below the decussation. Hypotonicity generally occurs immediately following UMN injury, and spasticity develops later in recovery. Upper motor neuron damage is also caused from conditions such as a cerebrovascular accident, traumatic brain injury, multiple sclerosis, and spinal cord injury.

The presentation of CP can be global mental and physical dysfunction or it can be isolated disturbances in gait, muscle tone, growth, cognition, or sensation. Along with the typical presentation of delayed motor development, abnormal muscle tone, and hyper-reflexia, other commonly seen complications from CP include communication difficulties, excessive drooling, osteoporosis, osteopenia, fractures, dislocations, pain, and gastrointestinal abnormalities. Constriction of respiratory ability can occur with poor trunk control and physical therapists should consider each body system to be effected by CP. Physical therapists may be working along side occupational therapists, speech therapists, social workers, psychologists, physicians, respiratory therapists, orthotists, educators, neurologists, etc., when treating patients with CP.

One characteristic that is evident in CP is abnormal muscle tone, ranging from almost no muscle tone at all to extremely high muscle tone. High muscle tone is more common than low muscle tone in CP, and indicates damage to the pyramidal tracts and will accompany increased reflex responses. The abnormal tone is the nervous system’s response to the initial brain damage and can fluctuate throughout the individual’s lifespan. The child with CP suffers from a chronic loss of inhibitory suprasegmental
inputs, causing hyperactivity of the alpha motor neuron, which presents as increased muscle activity. The child’s tone may fluctuate depending on positioning and tonal differences may be apparent in different parts of the body, with the trunk displaying low tone and any number of extremities displaying increased tone.

Spasticity is a frequently observed symptom following upper motor neuron lesions including stroke, brain injury, spinal cord injury and CP. Approximately eighty percent of children with CP will have spastic features, as damage to any part of the pyramidal tract will cause spasticity. Spasticity in children with CP is often characterized by a clasp knife quality where the limb catches at one point in the range, but is then released and able to move through the full range of motion. Limbs affected by spasticity may have hyperactive deep tendon reflexes, tremors, muscular hypertonicity, uncoordinated movements, and weakness. Spasticity is dependent on the velocity of the movement so the speed of the stretch is critical when testing patients. Generally, more rapid movements are effective in eliciting hyperactive stretch reflexes in patients with spasticity. In patients with spasticity, it is important to palpate the affected muscle groups, determine available ranges of motion, evaluate DTRs and perform tests for the Babinski sign and clonus. Recruitment of the corticomotor neuron pool is affected with the presence of spasticity, which results in inappropriate timing and poor grading of agonist and antagonist muscle groups. Many individuals with CP will often develop neuromuscular scoliosis due to the asymmetrical pull of spastic muscles. Due to the high rate of spastic features in children with CP, in this paper, treatment interventions will be focused on spastic CP. Spastic CP will be described as diplegia, hemiplegia, or quadriplegia.
Hemiplegic CP describes a child with one-sided involvement of the upper and lower extremities, with the upper extremity typically being more involved than the lower extremity.\textsuperscript{1} Due to the fact that pyramidal tract fibers cross over before they enter the spinal cord, damage to one side of the brain will produce abnormalities on the opposite side of the body.\textsuperscript{10} The hemiplegic child may present similarly to the adult that has suffered a stroke. The side of the body that exhibits the abnormalities, not the side of the brain where the damage occurred, names the hemiplegia. Hemiplegic cerebral palsy is one of the most common forms of CP, affecting approximately 30% of the children with CP.\textsuperscript{25}

Those with diplegia, will present with symptoms in bilateral lower extremities as well as the trunk.\textsuperscript{26} Diplegia results from hemorrhage of blood vessels that travel over a very fragile part of the pyramidal tracts near the lateral ventricles.\textsuperscript{10} Quadriplegia occurs when there is widespread and severe, bilateral damage done to the cerebral cortex. Quadriplegia affects all four limbs, and the trunk, limiting the individual much more than diplegia or hemiplegia. Children with quadriplegic CP more commonly suffer from seizures, mental retardation, visual and auditory deficits, and the overall prognosis of their condition is much worse.\textsuperscript{10} Quadriplegia and diplegia indicate bilateral brain damage, while hemiplegia indicates unilateral brain damage. There is always some degree of trunk involvement in individuals with CP.\textsuperscript{14}

Dyskinetic syndromes, known as athetosis or dystonic CP, affect about 10 to 20% of the entire CP population, and involve involuntary movements of the hands, arms, legs, or feet that are made worse by stress and during sleep.\textsuperscript{21} Movements in the mid-range are especially difficult for these patients because of the lack of postural stability and as the
limb moves farther away from the body the motor control decreases. Muscle tone may fluctuate from low to high and the child will exhibit slow, repetitive involuntary, movements.  

Ataxic cerebral palsy is the least frequently occurring type, affecting 5 to 10% of patients. Ataxic CP is characterized by impaired balance and coordination, causing the individual to ambulate with a very wide base of support and suffer from intention tremors. Children with ataxic CP will have low postural tone in the trunk and difficulty maintaining midline stability of the head and trunk in any posture. Most of these children will be ambulatory at some point in their lives, although ambulation may occur later than normally developing peers. Ataxic CP results from brain damage occurring in the cerebellum.

Muscle weakness has been identified as one of the primary deficits contributing to motor dysfunction in individuals with CP, and there is a strong relationship between muscle weakness and mobility. Injury to upper motor neurons decreases cortical input to the reticulospinal and corticospinal tracts, which in turn affects motor control, decreases the number of effective motor units, and produces abnormal muscle control and weakness. Weakness causes dysfunction in the performance of many activities of daily living, and will cause additional compensatory impairments of posture and movement. Research has indicated that patients with upper motor neuron lesions have decreased firing rates when maximal muscle contractions are tested. It has been reported that those with upper motor neuron damage have a dominance of type II muscle fibers in the affected extremities. It is possible that the length of time that the hemiplegia has been evident, relates to the rate of change of the muscle fibers. Children with CP have
decreased or altered movement, and their affected limbs have never experienced normal
movement and the strengthening that occurs through normal mobility. Muscle weakness
can lead to decreased movement, participation, and activity in the lives of children with
CP.\textsuperscript{10}

It is common for children with CP to also have a sensory processing dysfunction. Damage to the cerebellum, the cortical-basal ganglia-thalamic loop, or the cerebral
cortex and pyramidal tracts can lead to various sensory deficits in children with CP.\textsuperscript{10} Sensory deficits may cause the child to have decreased tactile and proprioceptive
awareness or decreased kinesthesia throughout the entire body. Children with CP often
have dysfunctional vestibular systems that do not process incoming information correctly
resulting in decreased body awareness and an aversion to certain positions.\textsuperscript{29}

All of the above mentioned impairments have an impact on the functional
mobility and ambulation abilities of the child with CP. Many children with CP
demonstrate decreased functional walking ability and it may be partially due to
pathological inefficiencies of the musculoskeletal system.\textsuperscript{26} Altered muscular tone, poor
coordination of agonist and antagonist muscle groups, and muscular weakness cause
altered joint forces that may result in musculoskeletal deformities in the child’s bony
structure and the surrounding soft-tissue. Torsion of long bones and soft-tissue
contractures cause dysfunction of lever arms across joint surfaces, which causes the child
with CP to expend more energy when ambulating, when compared to a typically
developing peer.\textsuperscript{30} Cardiopulmonary endurance, poor balance, and altered muscular
metabolism may also have an effect on ambulation abilities in children with CP.\textsuperscript{26}
EVALUATIVE ANALYSIS

It is common for a child to arrive for an initial physical therapy evaluation without the diagnosis of cerebral palsy. Many children are first diagnosed with “developmental delay”, or “prematurity” and it is then the responsibility of the therapist to communicate with the referring physician and refer to a neurologist if signs of CP are evident. The purpose of the assessment is to discover the functional abilities and strengths of the child as well as determine the primary and secondary impairments that the child has developed. Determining goals of patient and/or family and caregivers is also critical during the initial evaluation as it is with any patient population.

The examination should begin with close observation of the child with their family members. It is important to observe how the child normally is held and behaves when in their most natural environment. The therapist should observe if the child has appropriate head and trunk control for their age, looking for midline alignment and mid-range control. The therapist should note the natural positioning of the upper and lower extremities and if child is actively moving the extremities across midline. It is important for the therapist to observe how much assistance the child needs to be functional, whether they are in a wheelchair or an independent ambulator.

The therapist should discuss with parents the difficulties the child is facing and should listen to their previous experiences and feelings about the capabilities of their child. Having an open, honest conversation with parents/family/caregiver may help the therapist to understand their emotional state to establish good rapport and a trusting relationship. Many parents and caregivers, in particular mothers, can experience psychological stress in association with the burden of caring for a child with
developmental disabilities. When originally given the diagnosis, parents may be in shock and potentially disappointed when they realize their child will require assistance to perform activities of daily living and may never be independent.\textsuperscript{31} It is important that therapists have a positive attitude and outlook for the child’s future and educate the family about CP and the level of care their child requires.

The child should also be observed on a therapy mat with age appropriate toys for the child to explore. Observing the child when separated from the parents will give the therapist the chance to see any spontaneous movements that the child can make.\textsuperscript{21,29} Therapists should make note of the child’s movement patterns, use of vision, reaction to the support surface, initiation of movements, reflexive synergies and any other postural or movement abnormalities.\textsuperscript{29} Bilateral coordination as well as dissociation of limbs and body parts should be noted. Children should be assessed in all of the positions they are capable of including supine, prone, side-lying, short sitting, long sitting, side sitting, ring sitting, quadruped, kneeling, half-kneeling, standing, and walking.\textsuperscript{29} The child’s “preferred” positions should be noted but the therapist should try to safely transition the child through all available positions.\textsuperscript{21} When a child is avoiding a certain position, the therapist should further investigate why the child does not want to, or is unable to, maintain a certain position. Resistance to placement in certain postures may indicate an increase in tone, a structural problem, or an inability to adapt to the sensory inputs for that specific position. Children may have learned to avoid the excitation of unwanted reactions and therefore may avoid certain body positions, compensating elsewhere.\textsuperscript{21} The child should be assessed for equilibrium reactions as well as protective reactions.\textsuperscript{29}
The Gross Motor Function Classification System (GMFCS) is a 5-level classification system that is commonly used to assess the gross motor function of children with CP. The GMFCS assesses the child’s performance in sitting, transfers, walking, and wheeled mobility and was designed for use in the CP population. Level I would indicate that a child “walks without limitations”, level II “walks with limitations”, level III “walks using hand held mobility device”, level IV indicates “self mobility with limitations; may use powered mobility,” while level V indicates that a child is “transported in a manual wheelchair.” There are different age-bands in the GMFCS to allow this assessment to be used with children up to 12 years of age. Research has supported the content validity, construct validity and, inter-rater reliability on the GMFCS. The GMFCS focuses on the completion of certain gross motor skills, rather than the quality of the movement. The Gross Motor Performance Measure (GMPM) is another observational instrument that addresses the quality of gross motor skills in children with CP. The GMPM assesses alignment, coordination, dissociated movement, stability, and ability to weight shift and has excellent inter-rater, intra-rater, and test-retest reliability.

**Postural Control and Tone**

Postural control, specifically postural stability, is a necessary prerequisite for motor development in children. When a child is capable of exerting force against a surface to stabilize their body that is considered postural activity. Postural control is the ability of an individual to maintain their center of gravity over the base of support, when they are standing still, during motion, initiating movement or preparing to end a movement. The complex integration of visual, vestibular and proprioceptive
information and the commands from the central nervous system and neuromuscular responses are critical for postural control.\textsuperscript{32} When a child first performs a task, they receive sensory feedback and this allows them to make postural adjustments the next time that they perform the task. Feed-forward is a critical component of postural preparation and it occurs as the result of learning a task through repetitive experiences. In order for the child to learn these postural preparations, the task needs to be functional, goal oriented, and somehow interesting to the child.\textsuperscript{29} Postural stability develops over the first 6 years of life in typically developing individuals, but this development is slower in children with CP.\textsuperscript{18} Postural control abnormalities contribute to the lack of normal motor development in children with CP.\textsuperscript{32} It has been reported that children with CP tend to display their initial increase in postural stability after 31 months of age.\textsuperscript{18} It is important that the therapist notes the strategies that the child uses to transition between different postures, and if they have more than one strategy to complete a task or if they consistently move in consistent patterns. The therapist should also determine if the child has the ability to repeat movements or tasks and make small adjustments to improve their motor performance.\textsuperscript{29} The early Clinical Assessment of Balance (ECAB) is a 13-item assessment that estimates the postural stability of children with CP.\textsuperscript{18}

The Pediatric Balance Scale (PBS) is a modified version of the Berg Balance Scale and has been recommended for use in the CP population, GMFCS level I-IV.\textsuperscript{33} The PBS has good test-retest (ICC = 0.998) and inter-rater reliability (ICC = 0.997) in children with CP aged 5–15 years.\textsuperscript{34} It is possible that those with CP suffer a decline in functional balance as they get older,\textsuperscript{33} so it is important for therapists to reassess balance skills regularly throughout the duration of care.
Assessment of tone is an important component of the physical therapy evaluation. Signs of increased tone in a child include distal fixing, difficulty moving a body segment through range of motion, asymmetric posture, and retracted lips and tongue. Signs of decreased tone include excessive collapse of body segments, loss of postural alignment, and inability to hold the body vertical against gravity. It is possible for children with CP to have fluctuating tone, generally seen with athetosis and ataxic forms of CP. For children with quadriplegia, diplegia, and hemiplegia it is common for the trunk to have lower tone, while the extremities may have increased tone, making functional movements very difficult. The most commonly involved muscles tend to be the scapular retractors, the biceps, wrist flexors, and finger flexors as well as the hip flexors and adductors, knee flexors (especially medial hamstring) and ankle plantarflexors. Increased tone in the trunk may impair breath control for speech by preventing the diaphragm and chest wall excursion needed during inspiration and expiration. Low tone in the trunk can impair the child’s ability to develop postural control, righting and equilibrium reactions, as well as the ability to sit independently.

It is important for the therapist to determine if the increased tone is aiding or hindering the child’s overall function. General notes about postural tone should be made on the evaluation and any spasticity or high tone should be investigated further. Spasticity can be measured using the Modified Ashworth Scale (MAS) and is performed by the therapist passively moving a joint through its available range of motion and scoring it based on the perceived resistance to movement. The scale starts at 1, indicating no increase in muscle tone during the passive movement, and goes to 5, indicating that the joint is rigid in flexion or extension.
Primitive Reflexes

Assessment of the child’s reflexes will be done by a physician to make the official cerebral palsy diagnosis but they should also be assessed by the physical therapist. Primitive reflexes are normal early in life but should be integrated by twelve months of age. The primitive parts of the nervous system such as the spinal cord, the labyrinth of the inner ear, and the brain stem control these reflexes. Three primitive reflexes that affect posture and movement are the asymmetrical tonic neck reflex (ATNR), the symmetrical tonic neck reflex (STNR), and the tonic labyrinth reflex (TLR).

Stimulus for the ATNR is active or passive rotation of the infants head. When the head is rotated this causes the arm and leg of the side that the infant is looking toward to extend further, while the arm and leg on the side the child is turned away from take on a flexed position. The ATNR causes a change in muscle tone of the limbs and possibly the trunk. The ATNR is an appropriate reflex up to three months of age. Children with CP may never integrate this reflex and their volitional movement will be effected. The stimulus for the STNR is flexion or extension of the neck. When the neck is flexed, the upper extremities will flex and the lower extremities will extend. When the neck is extended, the upper extremities will extend, and the lower extremities will flex. A persistent ATNR reflex can affect the child’s ability to roll over while the STNR will prevent the child from reciprocal creeping or crawling.

For the TLR, the stimulus is the position of the labyrinths in the inner ear. If the child is laying on their back, if the neck is extended, this causes the labyrinths to be tilted, eliciting the reflex and the legs will extend and the shoulders will retract. When the neck becomes flexed or the child is laying on their stomach, the hips and the knees will flex.
and the shoulders will protract. If a strong TLR is present, movement of the head causes patterns of flexion or extension throughout the whole body, which will effect the child’s ability to maintain balance in the sitting position. All of these primitive reflexes should be integrated by the first year of life and if they are not they can severely decrease the number of postures the child is able to attain. It is critical the presence of these reflexes be monitored as they will continue to effect movement development.

**Musculoskeletal Assessment**

Although the neurological damage is not progressive, the secondary impairments such as musculoskeletal deformities are very progressive due to the decreased movement in children with CP. Contractures, soft-tissue restrictions and bony deformities are common findings. Range of motion measurements should be taken on evaluation and muscles should be moved through their full ranges of motion.

Children with CP are prone to the development of scoliosis due to muscle imbalances that cause asymmetries in the body. Neurological scoliosis can reduce cardiopulmonary function, decreasing chest excursions and abdominal movements, and contributing to morbidity and mortality in children with CP. Examination of the spine in all planes is very important. The spine should be inspected for correct alignment, symmetrical movements, and active and passive ranges of motion. Spinal extension, lateral flexion, and rotation are most easily assessed with the child in the seated position because the therapist is able stabilize the pelvis and move the trunk through various positions. Capital extensor muscles and lumbar extensor muscles are commonly shortened in the CP population. Any scoliosis, and excessive kyphosis or lordosis should be documented and may be important when prescribing for wheelchairs.
asymmetrical pull of the spastic muscles may cause the torso to collapse and rotate, causing increased rib prominence and pelvic obliquity, ultimately affecting the child’s ability to maintain an upright sitting posture independently.\textsuperscript{24}

Shortened rectus abdominis muscles and intercostal muscles may limit movement in the thoracic spine. The thoracic spine is important to consider in children with CP because of the coordinated movement that must occur for the breathing cycle to occur.\textsuperscript{24} Children with CP tend to have low tone in the trunk and have decreased balance of the trunk flexors and extensors when they are in the upright position. Most children with CP never develop the downward slant of the ribs that develops in normal children and this causes a decrease in the mechanical advantage of the pump-handle and bucket-handle motions during inspiration.\textsuperscript{18} Additionally, since they lack the muscle tone to stabilize their ribcage, the fibers of the diaphragm, especially the sternal fibers, actually cause depression of the xiphoid process and the sternum during inspiration, resulting in overall shallow breathing. The therapist should examine the respiratory excursion of the rib cage during breathing as well as perform respiratory function tests.\textsuperscript{29}

The therapist should continue the evaluation with an assessment of the upper extremity and the shoulder girdle. If the child has excessive axial extensor tone and poor control of the capital flexors and abdominal muscles they will most likely present with excessive tightness and reduced range of motion in the shoulder.\textsuperscript{37} The scapula fails to develop the proper amount of dynamic stabilization and may assume a downwardly rotated and forward-tipped position.\textsuperscript{29} The fixed position of the scapula is not advantageous to the child and motion may become restricted at the sternoclavicular and acromioclavicular joints.\textsuperscript{37} A pattern that is commonly seen in children with CP is
restrictions in passive flexion, abduction, and external rotation of the shoulder. The therapist will often also discover limitation in elbow extension, supination of the forearm, and extension of the wrist and fingers.\textsuperscript{29}

Muscle shortening of the hip flexors, adductors, and internal rotators may cause limitations in extension, abduction, and external rotation of the lower extremities in children with CP. The Thomas test can be used to determine if the child has hip flexor tightness. If a child has extreme tightness in any of the hip musculature it can result in hips that may be subluxed, dislocated, and potentially painful.\textsuperscript{29} The incidence of hip subluxation and dislocated is associated with greater limitations in activity and participation for the child with CP. Hip subluxations are more common in children with bilateral spastic CP who are non-ambulatory before the age of 5.\textsuperscript{35} Due to the abnormal forces on the hip, which have been present since birth, the children with CP do not experience the reduction in femoral anteversion that typically developing children do.\textsuperscript{38} Due to the lack of reduction of femoral anteversion, compensatory external tibial torsion often develops to keep the foot facing in the forward direction.\textsuperscript{29} When there is excessive femoral anteversion in combination with external tibial torsion deformities the soleus and posterior gluteus medius muscles are greatly impacted.\textsuperscript{38} The most important measure for the therapist to take and track is hip abduction with the knee and hip in the extended position.\textsuperscript{29}

If there is inadequate length of the quadriceps or the hamstring muscles the child will have limitation in the range of motion at the knee as well.\textsuperscript{39} Hamstring tightness can be assessed by performing a passive straight leg raise or measuring the popliteal angle.\textsuperscript{29} Excessive hamstring tightness may prevent the child from being able to assume a seated
position with 90-degrees of flexion at the hip and may cause a reduced stride length if the child is ambulatory. Tightness of the quadriceps musculature can be assessed by observing the position of the patella or by passively flexing the knee with the child laying prone. If the patella is sitting more superior than normal, that may indicate tight quadriceps. Any internal or external torsion of the tibia can be measured using the thigh-foot angle with the child in the prone position.

At the ankle, dorsiflexion is often limited and should be assessed with the subtalar joint maintained in neutral. The therapist should observe the position of the calcaneus in non-weight-bearing as well as in standing, if the position is accessible for the child. The three arches of the foot should be examined. The presence of any plantarflexion deformity must be carefully considered when prescribing an orthotic device for a child. The therapist should assess for soft-tissue restrictions in the hamstrings, gastrocnemius, and Achilles tendon.

When assessing strength, it is important that the therapist look at functional strength as well as the strength of individual muscles. Muscles may demonstrate different levels of strength depending on the position that the muscle is acting in, as well as if the muscle is being tested in open-chain or in closed-chain. For example, when plantarflexion strength is tested in open chain, the non-affected limb displays greater strength and endurance than the affected limb, but when assessed in closed chain the non-affected limb and affected limb fatigue at very similar rates. It is possible that this might be due to the fact that the gastrocnemius muscle functions as a two-joint muscle and works at different amplitudes at different knee angles. For the ambulatory patient, it is more beneficial to test the strength of the plantarflexors in the closed chain.
position.\textsuperscript{28}

**Gait Analysis**

The prerequisites of normal gait are (1) stable lower limb in stance phase, (2) clearance of the ground by foot in swing phase, (3) proper positioning of the foot in dorsiflexion in terminal swing, (4) adequate step length, and (5) maximal energy conservation.\textsuperscript{38} The therapist should observe the child walking from the front, the back, and each side. When assessing gait, the child should be barefoot with shorts on to allow for easily visualization of the thigh, knee, lower leg, ankle, and foot. The therapist should observe the entire kinetic chain when the child walks including the head and trunk.\textsuperscript{29} If child wears orthotics gait should also be observed with the child wearing the orthotic devices.\textsuperscript{39}

Gait deviations in children with CP are typically caused by weakness, abnormal bony alignment, muscle contracture, and muscle spasticity.\textsuperscript{29,38} As stated earlier, at the pelvis it is common to see hip flexor contractures with hip extensor weakness; and both of these factors contribute to the pelvis maintaining an anterior tilt during ambulation. Children with CP tend to have decreased rotation at the pelvis due to decreased push-off during gait by the gastrocnemius in addition to motion restrictions and weakness in the hips.\textsuperscript{29} It is common to see a drop of the pelvis on the swing side due to hip abductor weakness on the stance leg, known as a Trendelenburg gait. Those with CP may also demonstrate a trunk lean to the ipsilateral side as a compensation to attempt to counteract pelvic obliquity and to maintain stability during gait.\textsuperscript{41}

The ankle is the most commonly affected joint of the ambulatory child with cerebral palsy. Common impairments identified at the ankle joint include decreased
action of the tibialis anterior muscle in dorsiflexing the foot during swing phase, and
excessive plantarflexion during early to mid stance.\textsuperscript{42}

The term “crouch gait” is commonly used to describe gait pathology in children
with cerebral palsy. Crouch gait is characterized by slight flexion at the hips and knees,
excessive dorsiflexion at the ankle, as well as medial femoral torsion with accompanying
external tibial torsion.\textsuperscript{43} Crouch gait is normally progressive and without treatment will
get worse as the child grows.\textsuperscript{40} According to El-Kafy, any factor that reduces the
effectiveness of plantarflexion-knee extension coupling during the mid-stance phase of
gait will contribute to a crouched gait appearance including hamstring tightness, impaired
balance abilities, and lever arm dysfunction.\textsuperscript{38} Outcomes of surgical interventions for
crouch gait tend to be positive and provide the child with more extension at the hip and
knee, decreasing knee pain, and increasing the functional mobility of the child. Similar
to crouch gait, is jump gait, which is characterized by excessive hip flexion, knee flexion,
and plantarflexion at the ankle joint.\textsuperscript{43} When compared to normal gait, children with CP
displaying crouch or jump gait patterns, demonstrate less muscle activity in the rectus
terminis, soleus, gluteus medius, and gluteus maximus muscles when ambulating. The
Gluteus medius exhibits significantly decreased potential for support against gravity in
both crouch and jump gait. Due to the increased hip flexion in both of these gait patterns,
the hip extension moment arm is reduced which causes a reduction in the hip extension
acceleration. Therapists should consider strengthening the gluteus medius muscle in
children with either crouch or jump gait characteristics.\textsuperscript{43} Strengthening the gluteus
medius muscles has also been shown to decrease the appearance of a Trendelenburg gait
pattern.\textsuperscript{41}
The 6-Minute Walk Test (6MWT) is a common test used in the adult population but it has also been proven to be a valid and reliable submaximal exercise test in the spastic CP population, GMFCS levels I to III. The 6MWT can monitor changes in functional ability throughout childhood as well as assess function after surgical or nonsurgical interventions. In a study by Fitzgerald et al., 145 children with CP aged 4 to 17 years old completed the 6MWT and their results were compared to normally developing peers. The average distance covered by normally developing individuals was approximately 528 meters (m). Children with CP, GMFSC level III walked an average of 305 m, level II walked an average of 387 m, and those classified as level I walked an average of 439 m, indicating that decreased endurance and cardiorespiratory function have an impact on walking abilities. The 6MWT can be used upon evaluation, and periodically throughout treatment to track the progress of ambulation distance in children with spastic CP.

TREATMENT OF CEREBRAL PALSY

The role of the physical therapist when treating CP is to place the child in situations that offer opportunities for motor learning and development of new motor skills. The overall goal of treatment is to maximize active functioning of the child, ease daily care, and minimize secondary complications such as pain, joint subluxations, and contractures. Many of the secondary impairments involved with CP are potentially preventable and with the proper interventions, may improve the motor skills and activity level of young children with CP. By minimizing the development and severity of secondary impairments, the individual with CP may reduce the high lifetime cost of medical care. Many interventions will cause a reaction that is unique to the individual
patient, so all positions and suggestions for at-home handling should be experimented at therapy first.\textsuperscript{21} When choosing an intervention for CP the least invasive and most cost-effective option should be chosen and the effects of the outcome should be closely monitored.\textsuperscript{44} There is significant variability in the age at which intervention is initiated for children with CP and a wide variety of health professionals do not base their treatment on the most recent suggestions form the literature.\textsuperscript{21} It is important to identify patterns of rehabilitation services that are associated with positive clinical and patient-reported outcomes for patients with CP.\textsuperscript{9}

Some common interventions found in the literature consist of stretching techniques, massage, electrical stimulation, strength training, endurance training, weight-bearing, balance training, and treadmill training.\textsuperscript{45} Superior clinical results have been observed when children are participating in functional physical therapy activities when compared to attempts at normalizing movement.\textsuperscript{2} Positive symptoms of CP such as increased spasticity can be treated using pharmacotherapy, but negative symptoms such as weakness cannot, and commonly the negative symptoms have more of an impact on patient function.\textsuperscript{16} The greatest increase in gross motor development occurs between ages 18 months to 5 years of age, in children with CP, so receiving physical therapy intervention during the pre-school years can have a large impact on the child’s development of skills.\textsuperscript{18}
Managing Spasticity and Contracture Prevention

Hagglund and Wagner reported that Modified Ashworth Scale scores for muscle tone in the gastrocnemius-soleus muscle group increase up to 4 years of age, and then decrease to 12 years of age, in children with CP. Daily range of motion exercises and stretching are important to prevent or delay contractures secondary to spasticity, and to maintain mobility of joints and soft tissues. For children with spasticity, there is very weak evidence indicating that manual stretching will increase the range of motion, decrease the spasticity, or improve walking abilities. Stretching in combination with isometric muscle contractions have resulted in statistically significant improvements in range of motion and extensibility of muscle tissue. Muscles should spend at least 6 hours a day in an elongated position to help prevent or reduce the rate of progressive contractures. Massage has also been shown to be enjoyable for children with CP and has impacts such as muscle relaxation, increased tissue mobility, improved bowel movements, and reduced pain.

Severe spasticity is often treated with surgery, such as a lumbo-sacral selective dorsal rhizotomy, where dorsal nerve roots are cut from L1-S2. After the surgical procedure of the dorsal rhizotomy, physical therapy treatment focuses more on strengthening of the lower extremities, walking, and standing instead of stretching. Severe, whole body spasticity can also be treated with the implantation of an intrathecal baclofen pumps. The baclofen is infused directly into the subarachnoid space in the spinal cord, causing GABA-mediated inhibition of the spasticity. Since the site of action of the baclofen is in the spinal cord, the child will suffer fewer cerebral side effects. Patients must weigh at least 15 kg for the intrathecal baclofen pump to be implanted.
Spasticity can also be treated through oral medications or through botulinum toxin. Botulinum toxin is thought to produce a protein that blocks acetylcholine, and temporarily paralyze spastic muscles. Botulinum toxin (Botox) has been used to treat increased muscle activity in patients with CP for over 20 years. Botox is directly injected to an overactive muscle and produces temporary weakness of the injected muscle. In the lower extremities, the most common muscles that are injected with Botox include the adductors, hamstrings, gastrocnemius, and soleus. In the upper extremities the most frequent injection sites include the flexors of the arm, wrist, and fingers. The clinical benefit of Botox injections are normally seen within 7 days of injection, and the peak of effectiveness occurs around 4 weeks post-injection. Re-injection is usually required every 3 to 4 months. The safety and efficacy of using Botox in children has been researched widely, and many clinicians are concerned with the effect it has on the overall function of the child. Other adverse effects of the use of Botox include pharyngitis, nonspecific pain, falls, respiratory tract infection, bronchitis, vomiting, seizures, urinary incontinence, asthma, fever, flu-like symptoms, and infection.

Oral medications to treat spasticity are easy to use but can cause systemic side effects that interfere with function. Oral medications are most appropriate for children who have widespread spasticity, but only need a mild reduction in spasticity to gain function. Common oral medications are benzodizepins, dantrolen, baclofen, and tizanidine. Many of these medications can be used in conjunction with other spasticity management techniques, such as neuromuscular blocking techniques and intrathecal baclofen. Therapists must be aware of the systemic side effects that come alone with oral anti-spasticity medication such as drowsiness, and weakness.
Recent research has examined the effects of whole body vibration systems on spasticity of those patients with stroke, head injuries, spinal cord injuries, and CP. The whole body vibration (WBV) involves an individual standing on a vibrating platform which delivers low-frequency, low-amplitude mechanical stimuli that enters the body through the feet. Current research suggests that the vibration effects are mediated through the activation of muscle spindles and are transmitted by Ia fibers, which enhances cortical excitability of the specific muscle that received the vibrations. Simultaneously, the vibration stimuli also reduce activity in antagonistic muscles through reciprocal inhibition and supraspinal inhibition. This inhibition allows for a more balanced interaction between flexors and extensors.

This study by Cheng et al. examined the effects of WBV training on lower extremity spasticity and ambulatory function in children with CP. Sixteen individuals with spastic diplegia or quadriplegia were included in the setting and participated in 20 minutes of standing WBV delivered at 20 Hz with a vertical displacement of 2 mm. Each participant performed the WBV and a control condition on two separate days, one week apart. Each participant was assessed using active and passive range of motion measurements at the knee and ankle joints, pendulum test, Modified Ashworth Scale, Timed Up and Go (TUG), and the 6-Minute Walk Test (6MWT). The results of the study revealed decreases in spasticity according to the pendulum test and the Modified Ashworth Scale. Participants experienced a significant improvement in ambulatory function after the WBV as evidenced by improvements in their TUG and 6MWT scores. Active range of motion at the ankle joints also increased following WBV treatment. Due to the acute effects of WBV, it may be beneficial to use to increase individuals with CP.
active participation in other exercise training or therapeutic interventions. Strength Training

In prepubescent youth who are developing typically, changes that occur after a period of strength training appear to have more to do with neural factors such as; improvements in motor skills, increases in motor unit recruitment and firing rate, and changes in coordination, than with muscle hypertrophy. Children with CP have decreased motor function and it is possible that the adaptability of neural factors following resistance training is reduced in this group, further affecting their abilities to gain strength. Strength training has been controversial in the treatment of CP due to the concerns that it would increase the already abnormal muscle tone and spasticity, further increasing motion restrictions. Strength training programs have been shown to increase movement speed and muscle torque with no adverse affects, in individuals with CP. Strength training is effective in improving muscle strengths but there is less evidence proving that those strength gains have an affect on gait or motor function. Sixty five to 80% of 1-RM seems to be well tolerated by children with CP. Strengthening knee extensor muscles can help to improve crouching gait and stride length.

Individuals with CP appear to benefit from the same exercise training principles as people without CP, such as specificity of training, adaptation, overload, progression, and individualized training programs. The National Strength and Conditioning Association has guidelines for training children and adolescents and can be used as a starting point for exercise prescription for those with CP. The National Strength and Conditioning Association (NSCA) suggests starting resistance training by having the child perform one to three sets of 6 to 15 repetitions on a variety of single and multi-joint
exercises. Concentric and eccentric exercises should be performed and resistance should be gradually increased as strength improves. Research indicates that although intensity, as well as sets and repetitions are both significant factors when strength training, it is believed that intensity is the most important factor.

Progressive resistance exercise (PRE) training is a well-established training method, in which intensity progresses with time. This type of training consists of only small number of repetitions (usually 8 to 10), until muscle fatigue sets in, and progressively increase the amount of resistance. When a child is able to complete more than 10 exercises with good form, an increase in intensity would be appropriate. Therapists can add weights to a backpack and have the child continue to perform the task, but weight should not be increased by more than 10% at a time. A study by Scholtes et al. demonstrated significant improvements in isometric strength of the knee extensors, hip abductors, and leg-press strength in children with CP following a 12-week PRE training program. The improvements in strength were not correlated with a significant improvement in walking ability. Age-appropriate play and adaptive toys and games using the desired exercises are important to elicit the child's full cooperation.

The frequency of strength training should be 2 to 3 times per week on non-consecutive days with 48 to 72 hours of rest in between sessions. Researchers have determined a correlation between program duration and resistance training benefits and children with CP who are deconditioned may not be used to intense exercise, and may require a longer duration program than their typically developing peers, with 12 weeks being ideal. The NSCA suggests a youth resistance training program should be anywhere between 8 and 20 weeks in length. Five to 10 minutes of warm-up exercises
should be included consisting of dynamic body movements designed to elevate core body temperature, enhance motor unit excitability, improve kinesthetic awareness, and maximize active range of motion. Rest periods should be individualized between 1 to 3 minutes depending on intensity of exercise being performed.

Most research pertaining to strength training children with CP has focused on children labeled as GMFCS level I-III and further research is needed to investigate strength training in those individuals that are more impaired. Although single joint exercises may be effective for very weak muscle groups, children with CP suffer from impaired selective motor control, resulting in difficulty with performance of isolated joint movements upon request. Due to this impaired selective motor control, it may be more effective for resistance training programs to focus on functional, multi-joint activities such as sit to stand. Due to the complexity of some resistance training principles, resistance training programs may be more suitable for individuals that are at least 7 years old. It is also important to consider adjunct practices such as biofeedback, mental imagery and electrical stimulation in those patients who have difficulty with volitional movements.

It is beneficial to utilize research done on strength training of other upper motor neuron lesions and possibly apply those same techniques to children with CP. It is important to remember that with hemiplegic children, the “non-affected” side of the child should not be considered completely normal, due to the fact that approximately 10% of the descending motor tract fibers do not cross over to the other side. Therapists should consider isokinetic muscular strengthening, as this type of training program has been successful in increasing strength in patients that have suffered a stroke. It has been noted
that eccentric strengthening are well tolerated in stroke patients, and require decreased energy expenditure as compared to concentric strengthening. Rapid concentric movements stretch the antagonist muscle and cold possible increase spasticity in the patient, while eccentric exercises would avoid the increase in spasticity.\textsuperscript{52}

Although strength training has not been shown to increase spasticity the study by Scholtes et al.\textsuperscript{4} did find a significant decrease in knee flexion ROM due to decreased length of the rectus femoris muscle following a 12-week strength training regimen. Reduction of rectus femoris length in gait could lead to difficulty in clearance of the foot in initial swing phase, causing reduced walking ability (but no decreases in walking ability were noted in the study).\textsuperscript{4} These findings indicate that further research is needed on the topic and that muscle length needs to be taken into consideration when utilizing any kind of strength training program with children with CP.\textsuperscript{4}

The therapist should develop interventions that are aimed at increasing the postural control of child throughout the entire axial skeleton. It is important that the therapist specifically facilitate both the axial extensors and flexor muscles, particularly the oblique abdominal muscles that help the child to produce a powerful expiration needed during coughing and sneezing.\textsuperscript{29} Providing the child with a more stable base of support when sitting, possible with the use of a hip abduction orthosis, may allow the child to participate in more independent control of the center of mass of the trunk. The use of a standing frame with hip-knee-ankle-foot orthoses (HKAFO) will help the child to control their body position and work on upright postural stability.\textsuperscript{38}
Other Interventions

Standing programs can be used for children with CP and provide multiple benefits. Due to hip adduction contractures, many children with spastic CP stand with a decreased base of support and demonstrate a scissoring pattern when ambulating, even with assistance. A stander can be used to optimally position the lower extremities in a wider base of support and provide benefits such as weight bearing to improve bone density, stretching shortened muscles and improving ROM, pressure relief, and psychological well-being.\textsuperscript{29} Researchers concluded that standing 45 to 60 minutes each day is necessary, with 60 minutes being optimal, to increase range of motion at the hip, knee, and ankle.\textsuperscript{46} A study by Macias-Merlo et al., proved that hip abduction range of motion can be maintained over 1 period of 4 years if the child participates in a daily standing program.\textsuperscript{46} Standing programs seem to have a positive effect on all lower extremity range of motion, hip biomechanics, as well as spasticity. Standing programs also improve body functions, such as gastrointestinal mobility, and promote participation in upright activities at the level of the child’s peers.\textsuperscript{53}

Constraint-induced movement therapy was developed for use by stroke patients, but is also used in children with CP. This type of therapy was developed from the theory of “learned non-use” which is when following neurological insult, individuals will compensate by showing preference for using their less involved extremities. Variations of the treatment protocol exist but 2 fundamental principles are evident in all CIMT: constraint of the less-affected limb and mass practice of activities with the affected limb.\textsuperscript{54} The therapy is intense; the functional upper extremity is constrained, while the involved upper extremity is forced to participate in activities. Parameters include up to 6
hours of massed practice for a 2-week period, as well as constraint being worn up to 90% of waking hours. Due to the intensity of practice, increased use of the affected limb is argued to “induce expansion of the contralateral cortical area controlling movement of the more affected limb” as well as recruitment of ipsilateral cortical areas. When the child is participating in the mass practice, it is beneficial that the activity be something that interests and motivates the child. In a case study done by Schrank, a 10-year-old boy with tetraplegic CP was able to equalize weight bearing on the bilateral upper extremities and bilateral lower extremities through the use of CIMT as well as increase his independence in maintaining different sitting postures. This indicates that even though most CIMT is focused on training the upper extremity, individuals are able to make whole body functional gains.

A study performed by Psychouli and Kennedy attempted to provide CIMT in the home setting with more realistic parameters for children and families to follow. This study focused on children age 5 to 11 with a diagnosis of spastic hemiplegia and the interventions took place in the child’s home. Children wore a custom made splint, covering the child’s less affected hand and arm to just distal to the elbow. Parents were instructed to engage their children in functional activities of daily life, such as dressing, brushing teeth, preparing meals, turning pages in a book, and playing for 2 hours a day while wearing the splint. The study lasted 30 days. During the end of the study, a “Pac-man” like game was added to the intervention and this consisted of 20 minutes of play requiring unilateral manipulation of a joystick. The protocol was not adhered to perfectly, as most children wore the splint for only one hour a day, and did not wear it every single day during the study. Even with the protocol not being strictly adhered to,
every child in the study had improvements in upper limb function according to the outcome measures, The QUEST and the Melbourne Assessment. The group mean improvement was statistically significant and therapists also noted a clinically important change in function in most participants. The study showed that the improvements were less significant in children who were very low or very high functioning. Although there were difficulties with adherence to the program, this study reveals that restricting the less affected limb for 90% of the child’s day is not necessary to make functional improvements in upper extremity function.

Electrical stimulation is commonly used on children with CP, and normally it is either threshold electrical stimulation (TES) or neuromuscular electrical stimulation (NMES). There is conflicting evidence available on the effectiveness of electrical stimulation on strength, but when used, NMES with a visible muscle contraction is the preferable technique. NMES used in conjunction with task-oriented practice was found to improve sensory awareness, strength, gait parameters, and passive and active range of motion. Another treatment strategy that can be utilized by physical therapists is hippotherapy. The American Hippotherapy Association defines hippotherapy as a treatment strategy that uses the movement of the horse to address body structure and function, activity limitations, and participation restrictions. The APTA recognizes hippotherapy as an appropriate neuromuscular and therapeutic exercise for treating individuals with neuromuscular diseases. Many body systems are incorporated into hippotherapy, including the sensory, limbic, musculoskeletal, vestibular, and ocular systems. Hippotherapy provides children with an open, unpredictable task that takes
place in a nonclinical environment, and provides children with internal feedback.

Research has indicated that hippotherapy improves self-efficacy, confidence, as well as self-esteem in children with CP.\textsuperscript{56} Hippotherapy research on children with CP has also indicated significant positive effects on balance, performance of daily activities, head and trunk control, upper extremity reaching, postural control, alignment of the pelvis, symmetrical hip movement, as well as tone reduction.\textsuperscript{3,57}

Physical therapists can also help the individual with CP by prescribing and evaluating certain adaptive equipment. Seating systems and custom wheelchairs can be used to prevent and/or decrease changes in body structure and can help to improve function, mobility, school participation, educational success, and overall quality of life.\textsuperscript{24} Being properly seated in adaptive equipment has been shown to improve vital capacity, forced expiratory volume and expiratory time for children with spastic CP aged 5 to 12 years old.\textsuperscript{58} Researchers\textsuperscript{59} suggest that customized seating improves sitting posture and head control while allowing the child to participate in daily activities. For children who are non-ambulatory, customized seating has been shown to increase sitting time, attention and engagement to classroom activities, and participation.\textsuperscript{59} Walkers, crutches, and gait trainers can be used to improve ambulation abilities.\textsuperscript{13}

\textbf{Gait Training}

When parents are first told that their child is going to suffer from motor impairments due to cerebral palsy, one of the first questions they always ask is whether their child will ever be able to walk. Physical therapists need to be realistic with answers that they give to parents, but should always instill a positive, hopeful message. The ability for children to ambulate is an important goal for families of young children with
CP and is often a focus of early physical therapy treatment. Therapists must consider the recent research published pertaining to the prognosis of gross motor function in CP. Cross-section studies have reported characteristic patterns of motor development, according to the severity of the condition and the patterns have been used to create motor growth curves for the CP population. The Gross Motor Function Classification System (GMFCS) and the Gross Motor Function Measure (GMFM) are considered valid and reliable tools that clinicians can use to measure functional limitations in children with CP up to the age of 12 years old. By using the GMFCS therapists are able to classify the severity of a child’s functional limitations into one of five levels. Children classified as Level I are mildly affected and are normally able to achieve most of the activities of their age-matched non-impaired counterparts. A child that is classified as Level V are the most impaired and are severely limited in the activities, having little ability to control their head and trunk. Rate of functional limitation in mobility, manual dexterity, speech, vision, hearing, and cognition have been shown to correlate to a child’s GMFCS level, making it an excellent evaluation tool. Physical therapists can also use the International Classification of Functioning, Disability and Health for Children and Youth (IFC-CY) for a structural basis to treating CP. The IFC-CY can help the physical therapist in the proper selection of measurement tools, both in goal-setting and decision making processes to determine the most meaningful outcomes. Use of the WeeFIM is another way therapists can measure the functional abilities of the child with CP. This measurement is very useful to the therapist and the family because it provides information about how much assistance the child needs to perform the activities of daily living.
Independent ambulation is an important skill and limitations in ambulation abilities create potential barriers for participation in physical, recreational and social activities, which may affect the development of friendships and interactions with peers. Sitting without support and pulling to stand by 2 years of age have been associated with the ability to ambulate in the future. Research by Fedrizzi et al., found that children with CP who were able to rapidly achieve various motor skills in the first 2 years of life (eg, roll from supine to prone and sitting without support) are able to walk independently between the ages of 3 and 5. A study completed by Begnoche et al., focused on the development of 80 children with CP, GMFCS level II or III, over a one year period and tried to determine what factors effect a child’s ambulation abilities. At the beginning of the study, the children were between 18 and 30 months of age. Researchers examined postural control, reciprocal limb movements, functional strength, intrinsic motivation, as well as family factors including support and opportunities provided by the family and others to foster the child’s independent ambulation. Children were assessed at the beginning and end of the year long period using the GMFM 66 B&C, which is the basal and ceiling approach to the GMFM. Begnoche et al. determined that functional strength was the only significant predictor of independent walking. In this context, functional strength is defined as the ability to generate and sustain muscle forces to move the body through space in a sit-to-stand task. Authors recommend therapists use functional strength training (eg, closed-chain sit-to-stand and stand-to-sit) and task-specific exercises to reach the goal of independent ambulation. The closed-chain exercises should be functional, mimic everyday activities, and be fun for the child. These activities have been proven to increase strength and functional ability in children with
Although postural control alone was not considered to be a predictive factor in ambulation abilities, when the child is performing sit-to-stand tasks, they require a certain degree of dynamic postural control to complete the movement. The results from this study indicate that if a child with CP is able to independently transition from sitting to standing, and back to sitting, the child may be ready for therapy to focus more on independent ambulation.\textsuperscript{60-62}

There are many physical therapy techniques that can be used to improve a child’s ability to walk as well as attempt to correct any limb deformities that are present. Many therapists prescribe some sort of lower extremity orthotic device in an attempt to correct the child’s biomechanical alignment. By normalizing alignment, the child may be able to focus on training the unrestricted parts of their body.\textsuperscript{38} According to the International Society of Prosthetics and Orthotics, lower limb orthotics may be used to correct and/or prevent deformity, provide an improved base of support, facilitate training in motor skills, and improve the efficiency of gait.\textsuperscript{40} When using lower limb orthoses, effects also include influencing the joints proximal to the orthoses by altering the line of action of the ground reaction force during standing and walking.\textsuperscript{38} In a study by El-Kafy including 57 children with CP, he determined that orthotic intervention using static ground reaction ankle foot orthoses (AFO) combined with a TheraTog strapping system had a greater effect on improving gait for children with spastic diplegic CP, as compared to a more conventional treatment with or without TheraTogs.\textsuperscript{38} El-Kafy found that the solid ground reaction AFOs were able to overcome femoral anteversion and compensatory external rotation and helped to improve plantarflexion, knee extension coupling, and the knee and hip extension angle that was achieved during the mid-stance phase of gait.\textsuperscript{38} El-Kafy also
determined that children were able to improve their gait speed, cadence, and stride length when wearing the ground reaction AFOs. El-Kafy also suggests that incorporating the TheraTog strapping system can increase proprioceptive and tactile input and can normalize muscle lengths to improve firing of recruitment patterns in children with CP.\textsuperscript{38,39}

It is important that therapists consider each child individually when prescribing an AFO device and should work closely with the orthotist during this process. The child and family must be educated about the condition as well as the role of the prescribed orthosis and when the child should wear it. It is also imperative that the AFO be donned correctly, with the foot sitting all the way back in the AFO. At each visit, therapists should inspect the child’s skin under the AFO to check for any areas of increased pressure or skin breakdown. Therapists should make sure the parents, caregivers, and teachers at school, are using the orthosis correctly.\textsuperscript{38}

Theratogs orthotic undergarment and strapping system are used to improve body awareness, postural stability, and functional joint alignment during therapy sessions, but can also be used during normal activities outside of the clinic. Laracca et al. have recommended that twister bands be attached from the leg to the pelvis in order to pull the leg into external rotation and control excessive femoral anteversion, which can potentially correct the appearance of lower extremity internal rotation and improve ambulation.\textsuperscript{39}

Many of the muscle impairments evident in CP have an impact on walking ability, including both speed and endurance.\textsuperscript{4} One way to improve speed and endurance capabilities is through the use of body weight supported treadmill training.\textsuperscript{63} Endurance
training is useful to improve the aerobic endurance of children with CP. A training heart rate of 75% of maximum heart rate is beneficial. Treadmill training is used to improve endurance, change certain parameters of the gait pattern, and improve strength in children with CP. The use of partial body weight supported treadmill training can even be implemented with very young children. The weight bearing is useful to improve bone mineral density in children who are unable to stand and weight bear on their own. Locomotor treadmill training (LTT) has shown significant improvements in GMFM-66 scores and led to accelerated motor milestones in children with CP. Studies have shown that intervention protocols with higher intensities or longer durations yield better results than shorter or less intense protocols in school-aged children. The treadmill can help clinicians overcome space constraints, reduce physical demands, and establish a convenient set-up for gait evaluation. The best parameters for LTT are yet to be discovered, but many studies have noted significant improvements in walking abilities and increases in gross motor function related to standing and walking. A study by Mattern-Baxtern et al., determined that even home based treadmill training, supervised by a PT once a week, can accelerate the onset of walking with and without an assistive device, improve walking speeds, and overall mobility. Children with CP may display increased cadence and decreased stride lengths, as well as increased dorsiflexion, knee flexion/extension, and hip flexion angles, when ambulating on the treadmill.

One modality that can be incorporated into gait training is the use of electrical stimulation. For many years physical therapists have used functional electrical stimulation (FES) to activate certain muscle groups at specific times during the gait pattern. The NESS L300 is made by Bioness and can deliver electrical stimulation to the
fibular (peroneal) nerve, the hamstrings, and the quadriceps muscles. For a patient with crouch gait, Khamis et al. utilized the NESS L300 on the quadriceps muscle and identified improvements in the patient's ability to extend his knee during the stance phase of gait. The patient progressed from using a step-to gait pattern to a step-through with the FES device. The patient also increased the distance and time he was able to ambulate and improved his upright posture. Prosser et al. utilized the Walk Aide system on ambulatory CP individuals with foot drop. The Walk Aide system delivers asymmetrical biphasic surface electrical stimulation to the common fibular (peroneal) nerve that is triggered by a tilt sensor programmed for each individual, which improves foot clearance during the swing phase of gait. When using the FES participants demonstrated significant improvements in dorsiflexion at initial contact as well as during the swing phase of gait.

**PROGNOSIS**

Although the neurological lesion is not progressive, the secondary impairments that a child develops and their gross motor abilities will change over their lifetime. Children may increase strength and improve their gross motor performance over the years or they could decline in function. Caregivers, parents, physicians, and therapists should not assume that further therapy would be unhelpful when the patient seems to plateau in their skill development. The GMFCS is a valid, reliable tool used to classify children with CP into one of 5 levels, and can provide some prognostic indicators for future functional mobility. It is a useful evaluative tool because it can be used as a predictive measure to provide parents with a general idea about the highest level of function that their child will reach. According to research by Palisano et al. in Ontario, Canada,
almost all children classified as GMFCS level I are able to ambulate in the home, school, and community environment by age 3. It is rare that children classified as level V will ever be able to move around their environment without physical assistance are likely to be carried or transported using a wheelchair at all ages. If a child remains non-ambulatory at 8 years of age, there is very little chance they will ever become ambulatory. It is also common to see gross motor skill development plateau around the age of 8.

For children classified as GMFCS level II, the probability of walking at age 4 varies from 39% outdoors, to 76% in the school setting, with the probabilities improving at age 9 to 75% ambulating outdoors, and 93% ambulating in the school setting. By age 18, most children classified as level II maintain their ambulation abilities, with 93% ambulating in schools, 90% ambulating outdoors. Children that are classified in GMFCS level III, have a less than 50% chance of being ambulatory in any setting at the age of 5. By age 18, there is a 50% chance that these children labeled as level III will be ambulating in the home, outdoor, or school setting. Those who are not independently ambulatory at 18 are likely to use physical assistance of a family member to ambulate in the home, while they will use some sort of wheeled mobility to move around outdoors and in the school setting.

For those children and adolescents classified as GMFCS level IV, the probability of them requiring some form of wheeled mobility increases with age. By age 18, 57% of children with level IV will require wheeled mobility in the school setting, 45% outdoors, and 38% will use wheeled mobility in their homes. Many individuals report the use of
crawling, or furniture walking in the home, which is not socially acceptable in the other
settings.\textsuperscript{62}

**Growing Older with CP**

It is important for individuals with CP, families, and therapists to consider that CP
is not a “pediatric” condition and the care and treatment of these individuals should
continue throughout their lifespan. In a 1940 to 1950 birth cohort, almost 85% of those
who have reached the age of 20 years survived to 50 years.\textsuperscript{67} Although the neurological
insult does not progress overtime, the secondary complications of CP are known to
change overtime which will affect the independent functioning of the individual with CP.
Musculoskeletal impairments may worsen over time, individuals may experience pain or
weight gain due to inactivity, or physical fatigue. Teens and young adults classified as
GMFCS level IV-V have a 15-80\% of developing neurological scoliosis, and 30\% will
develop scoliosis with a Cobb angle of more than 40 degrees.\textsuperscript{24} Many of these factors can
contribute to changes in motor functioning for adolescents and adults with CP, including
a decrease in walking ability.\textsuperscript{12} Research performed by Day and colleagues, noted that
those individuals who are ambulatory at 10 years of age and at 25 years of age have a
high likelihood of maintaining ambulatory abilities for the next 15 years. If at 10 years of
age a child has some difficulty with walking, they have an equal chance of progressing
their abilities or displaying a decline in gross motor skills over the next 15 years. By the
age of 25, the change of gaining abilities is very slim, while the possibility of declining is
significant.\textsuperscript{68}

The healthcare system changes dramatically when the classification changes from
pediatric or adolescent to adult.\textsuperscript{68,69} Increased lifespans for those with chronic illnesses
means that many more young people experience the transition from adolescence to adulthood. More than half a million chronically ill youths, including those with CP, cross the threshold to adulthood each year due to innovative technologies and medical advances.\textsuperscript{70} Many young adults with CP are dissatisfied with the healthcare services that they receive, and many report feeling that they are more knowledgeable on CP than the medical professionals providing them with care.\textsuperscript{69} Some factors have been discovered that allow for better outcomes in the care of adult CP patients and these include; collaboration between pediatric and adult providers, including the family in the care of the young adult, structuring services around the young adults development and maturity, and approaching the transition in a flexible way.\textsuperscript{69,70} As a result of improvements in healthcare, mortality rates have declined approximately 3.4\% per year over a 20-year period since 1983 in people with severe CP.\textsuperscript{67}

**CASE REPORT**

**Case Description: Patient History**

The patient is an 11-year-old male receiving physical therapy services through Lee Memorial Health System’s Children’s Rehabilitation Center of Naples. The patient was born at 25 weeks gestation via Cesarean section. He was diagnosed with right -sided spastic hemiplegic cerebral palsy at the age of three years old. He wears prescription glasses and is followed by an eye doctor. The patient lives at home with his mother, maternal grandmother, and younger brother. He previously received skilled PT services through NCH Greentree clinic from the ages of 3 to 8. He received Botox injections into right gastrocnemius muscle approximately 2 years ago. His mother’s biggest concerns regarding gross motor skills include the patient’s inability to clear his foot during the gait
pattern and the frequency of falls. She also reports that she would like him to be able to ride a bicycle with training wheels.

**Clinical Impression #1**

The patient is ambulatory independently but demonstrates gait abnormalities. He currently has a hinged ankle-foot orthotic and a supra-malleolar orthotic but he has outgrown them and they do not appropriately support the patient during the gait pattern. He demonstrates over pronation of the right foot with increased calcaneal eversion caused from a tight Achilles tendon and gastrocnemius muscle. He demonstrates decreased foot clearance of right foot has a circumduction gait pattern with external rotation of the right lower extremity observed. The patient is seen in the outpatient setting and does not receive any PT/OT/Speech services through his school. The patient is able to effectively communicate with therapists but tends to lose attention to task easily and requires re-direction to therapist directed activities. The patient is appropriate for physical therapy services to improve strength, endurance, balance strategies, maintaining ROM, and improving gait kinematics.

**Examination**

A systems review was completed, assessing the cardiovascular/pulmonary system, integumentary system, musculoskeletal system, neuromuscular system, and communication ability, affect, cognition, language, and learning style. The cardiovascular/pulmonary system, integumentary systems were unimpaired based on visual inspection of respiration, pulse rate measurements, and visual observation of skin. The patient has effective communication skills and is not seen by a speech therapist. He frequently perseverates on certain topics and requires re-direction to therapist directed
activities. He tolerates handling and is alert and cooperative during physical therapy evaluation, although he may require encouragement to participate in certain tasks. Upon review of the musculoskeletal and neuromuscular systems, multiple abnormalities and limitations were identified and are described below.

**Posture and Observation**

The patient demonstrates asymmetrical tone in his trunk and the right upper extremity and right lower extremity are hypertonic. He presents with a 1-inch leg length discrepancy with the right leg being shorter than the left leg. He has a pelvis obliquity with the right ASIS/PSIS lower than the left ASIS/PSIS. In standing in bare feet, the patient demonstrates right sided over pronation and increased calcaneal eversion. In sitting the patient demonstrates increased thoracic kyphosis. There is observed atrophy of right-sided gastrocnemius, hamstrings, quadriceps, biceps, and triceps. He frequently utilizes upper extremity support while in the seated position indicating suspected weakness of core musculature.

**Gait and Functional Mobility**

The patient ambulates independently. He demonstrates over-pronation with increased calcaneal valgus with slight internal rotation of the right lower extremity. He ambulates with circumduction of the right lower extremity with external rotation observed at the hip. He demonstrates flat foot initial contact. He occasionally demonstrates high steppage gait with the right knee excessively flexed. He is able to ascend from the floor to standing through right half kneeling but he requires external support. He is able to stand through left half kneeling independently. He is able to ascend and descend stairs using a reciprocal pattern with one hand supported on the railing. He is
unable to propel pedal walker therapy device. He was able to balance on his left lower extremity in single leg stance for 10 seconds with his eyes open and 2 seconds with his eyes closed. He was able to balance on his right lower extremity in single leg stance for 2 seconds with eyes open and 1 second with eyes closed. He ambulated 241 meters during the 6-minute walk test.

**Range of Motion**

Patient has functional range of motion available in bilateral upper extremities. He demonstrates 12 degrees of active dorsiflexion and 20 degrees of passive dorsiflexion in the left lower extremity with the knee extended. He has limited range of motion in the right lower extremity as evidenced by -30 degrees of active dorsiflexion and 0 degrees of passive dorsiflexion (able to attain neutral) with the knee extended, indicating decreased muscle length of the gastrocnemius muscle. He has decreased muscle length of right hamstring musculature as evidenced by a popliteal angle of 130 degrees with the hip in 90 degrees of flexion.

**Strength**

The patient demonstrates decreased functional strength in core (abdominals and trunk extensors) and right lower extremity. Strength of the left upper extremity and left lower extremity was measured to be within functional limits and he is able to perform all ADLs with his current strength level. Strength of right upper extremity measured to be grossly 4/5. Hip flexion is measured to be 3+/5, hip abduction 3/5, hip extension 3+/5, knee extension 3+/5, dorsiflexion 0/5 with no active contraction observed. He has decreased core strength, as demonstrated by the inability to complete a sit-up without the use of upper extremities. He is able to hold a v-up position for 4 seconds.
Sensation/Proprioception

Tested sensation by having patient report location of tactile stimulation with eyes closed. Tested proprioception by asking patient to identify the position of their great toes as either “up” or “down” with eyes closed. Patient’s sensation and proprioception evaluated as normal.

Clinical Impression #2

The patient would benefit from consultation with Orthotist and new orthotic devices. Therapist recommends KiddieGait dynamic AFO and SureStep SMO. He would also benefit from a formal evaluation for appropriate use with the Bioness L300 device to improve dorsiflexion and foot clearance during gait. The patient would benefit from strengthening programs targeting his core and right lower extremity. He would benefit from implementing a daily stretching program to improve the length of his right hamstring and gastrocnemius musculature. Although the patient can’t become distracted and perseverate on certain topics, he patient responds to redirection via verbal cues. He sometimes requires numerous verbal cues to remain on task.

Interventions

- Week 1: Initial Evaluation
- Week 2: Treadmill ambulation forward 1.6 mph, incline 5 x 6 minutes, backward ambulation 0.9 mph x 3 minutes, side stepping at 0.6 mph x 1 minute each way. Manual stretch to hamstrings in supine 1 minute x 3 reps. Standing gastrocnemius slant board stretch 1 minute x 3 reps. Soft tissue massage/myofascial release to right hamstrings and gastrocnemius musculature. Side-lying clam shells RLE 12
reps x 2 sets. Stair climbing 12 stairs x 2 reps. Application of kinesiotape to right anterior tibialis.

- **Week 3**: Bike level 1 x 5 minutes. Standing gastrocnemius slant board stretch 1 min x 3 reps. Manual hamstring stretch in supine 1 min x 3 reps. Bridges x 10 reps. Side lying clams with yellow theraband 10 reps x 2 sets. Soft tissue massage/myofascial release to right hamstrings and gastrocnemius musculature. Orthotist present to measure and cast patient for orthotics.

- **Week 4**: Soft tissue massage/myofascial release to right hamstrings and gastrocnemius musculature. Manual supine hamstring stretch 1 min x 3 reps. Standing gastrocnemius stretch 1 min x 3 reps. Applied kinesiotape to right tibialis anterior to facilitate dorsiflexion. Worked on treadmill training at 1.7 mph and incline 5 x 6 minutes, backward 0.9 walking x 3 minutes, side stepping 1.5 minutes each at no incline- encouraging use of no hands on hand rails. Bridges x 12 reps x 2 sets. Stair climbing 12 stairs x 3 reps.

- **Week 5**: Patient absent due to being out of town for Spring Break trip.

- **Week 6**: Bioness representatives present. Patient fit with Bioness right LE unit using quick-fit electrodes applied to anterior tibialis. Assessed effectiveness in clinic, on treadmill at 1.5 mph at both incline 0 and incline 5. Assessed ankle stability with Bioness activations during single leg stance rebounder ball toss activity. Tolerated 30 mA intensity. Noted significant improvement with application of Bioness facilitating a consistent heel toe progression during ambulation on both level and inclined surfaces. Improved ankle stability noted during gait and single leg stance activities.
• Week 7: Assessed fit of new KiddieGait AFO and SureStep SMO. Worked on ambulation with Bioness device over level ground and on treadmill. Treadmill forward 1.7 mph incline 5 x 7 minutes, backward 1.0 mph x 4 minutes, side-stepping to the right and left 1.0 mph x 3 minutes each way. Bridges x 10 reps x 3 sets. Side-lying clamshells with yellow theraband 10 reps x 3 sets. Stair climbing 12 stairs x 4 reps.

• Week 8: Re-evaluation. Side-lying clamshells with red theraband 12 reps x 2 sets. Bridges 10 reps x 3 sets.

Outcomes

Patient received SureStep SMO, KiddieGait AFO, and a DAFO 9 night splint for the right lower extremity. He has initiated daily use of each orthotic with no adverse effects reported. He demonstrates improved heel-toe progression and increased foot clearance during ambulation when wearing orthotics. He also demonstrates improved medial/lateral ankle stability when challenged in single leg tasks. The Bioness L300 device also significantly improves the patients’ heel-toe progression and foot clearance of the RLE. The patient occasionally complains of discomfort after using the Bioness L300 device for longer than approximately 20 minutes, but normally he can be distracted by activity or exercises. The Bioness L300 cannot be worn as the same time as the KiddieGait AGO as the LE cuff will not fit beneath the AFO, but it can be used with SureStep SMO. The Bioness representatives are currently in the process of trying to obtain a personal Bioness L300 device for this patient through his insurance. Patient has made improvements in lower extremity strength: hip flexion 4-/5, hip abduction 3+/5, hip extension 3+/5, knee extension 4-/5, knee flexion 4/5, dorsiflexion 0/5. Patient continues
to demonstrate -30 degrees of active dorsiflexion but is now able to attain 3 degrees of passive dorsiflexion. He is now able to balance on RLE for 5 seconds with his hands on his hips. He is able to ascend and descend stairs using a reciprocal pattern and no upper extremity support on railing. He ambulated 297 meters on 6 minute walk test (without AFO or Bioness L300 device).

**Reflection**

This was an excellent patient to be able to work with as he has a neuromuscular disease but we were able to treat him using many orthopedic principles. He was high functioning enough that we could challenge him on the treadmill and with therapeutic exercises. We utilized a lot of the same principles that we would have used with a typical orthopedic patient and I saw improvements in the patient with CP. Over 7 weeks the patient demonstrated minor improvements in his strength, endurance, and balance skills and believe that if these exercises are further progressed he will continue to show improvements. We also provided him and his mother with a home exercises program that listed activities that they could practice at home to ensure carry over between session and progress towards goals.

Although this patient had normal cognitive functioning and is in classes with typically developing peers, he is an 11-year-old boy and has trouble remaining on task in therapy. This required constant engagement with the patient and verbal or tactile cues when he was drifting off-task. He has trouble multi-tasking and I sometimes had to require the patient to refrain from talking until he completed the exercise or task at hand and then allow him break time where he could tell a story.
SUMMARY

In summary, physical therapy plays an essential role in the overall treatment and functioning of children with Cerebral Palsy. In treating patients with CP, it is important to address strength training, aerobic training, stretching, along with other interventions focusing the motor impairments involved with CP. The question remains whether the effectiveness of current training programs could be improved by individually tailoring the exercises or by emphasizing the weakest muscle groups. Although, each child with CP will develop and progress differently, it is important for clinical guidelines to be developed in the treatment of CP. It is important to consider the research that has been done on other conditions with upper motor neuron damage, as this information can possibly apply to children with CP and improve the standards of care. Therapists can utilize strength training principles and should progress and challenge patients with CP in their exercise regimens.
REFERENCES


