Use of modified core strengthening and stabilization exercises in conjunction with Dynamic Movement Orthoses (DMO) to increase trunk control and grasp control in a 12 year old boy with Spastic Diplegic Cerebral Palsy.

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Abstract

Purpose: The purpose of this study is to examine the benefits of dynamic movement orthoses (DMO) used in conjunction with a modified core strengthening and stabilization program to increase trunk and grasp control in a 12 year old boy with cerebral palsy (CP).

Methods: The patient is a 12 year old boy diagnosed with spastic CP at birth with significant involvement in all extremities. The patient reported to a hospital based outpatient physical therapy clinic. Physical therapy services were administered once a week for one hour sessions. The program includes exercises for core stabilization along with a wearing schedule of DMOs for the trunk and upper extremities. Therapy is carried over at home daily for an hour. Progress was determined by observational functional changes per report of his treating physical therapists. Results: With the use of a modified core strengthening and stabilization program, a DMO wearing schedule, and a carryover home program, this patient demonstrated increased strength, stability of the core muscles, increased functional mobility of reaching and grasping and increased tone management.

Conclusion: This data suggests that children with spastic CP may benefit from a modified core strengthening and stabilization program in conjunction with a DMO wearing schedule and a home carryover program.

Keywords: spastic cerebral palsy, children, core strengthening, core stabilization, dynamic movement orthoses (DMOs), tone,
Introduction

Cerebral palsy (CP) is one of the most common causes of activity limitations in children and has been defined as a non-progressive disorder of posture and movement.\(^1\) CP occurs due to a lesion in the brain which is part of the central nervous system (CNS). As a result of this lesion, the child is left with limitations that affect their control of movement and posture. CP is also one of the most common birth defects, with an estimated 10,000 babies per year diagnosed in the USA.\(^2\)

One of the main activity limitations that results from CP are fluctuations and changes in tone. Tone is defined as the continuous and passive partial contraction of muscles and can be normal or abnormal.\(^1\) With normal muscle tone, the muscles of the body are in a state of tension known as resting muscle tone. This state of tension is regulated by the brain, sending messages to the muscles so that there is an even balance between contracting and relaxing muscles.\(^3\) This balance also allows for smooth, coordinated movements as well as maintenance of static and dynamic positions. Abnormal tone occurs when the messages to the brain are disrupted or are incorrect as in CP. Injuries to the central nervous system result in abnormal tone.

Muscles can display an increase or decrease in tone, however in most instances a child with CP displays both an increased tone in some muscles and a decrease in others. Spasticity is “a motor disorder characterized by a velocity-dependent increase in tonic stretch reflexes with exaggerated tendon jerks, resulting from hyperexcitability of the stretch reflex.”\(^1\) Normal tone is crucial for posture in sitting, standing, and in the ability to control the movement of muscles.\(^16\)
Children with CP benefit from physical therapy interventions by helping to restore function and improve mobility. Physical therapy interventions can include exercises for strengthening and flexibility, gait training, endurance, balance and orthotics interventions. These interventions are considered more conservative measures and are specifically designed to treat deformities, improve function and delay surgical procedures.

A particular type of exercise program, known as core strengthening and stabilization, specifically targets the muscles that make up the core including the inner and outer abdominal muscles running along the length of the trunk and torso. When these muscles contract they stabilize the spine, pelvis and shoulder girdle and create a solid base of support so that we are able to generate controlled movements of the extremities. A core stabilization and strengthening program can be modified for children with CP to aid with fine and gross motor control movements. In addition, it can improve gait, balance, postural control, stability and reducing muscle tone.

In addition to core stabilization exercises, orthotics have been widely used for children and adults with CP. Orthotics can be worn to prevent the further development and progression of deformities or to correct existing deformities. Both rigid and dynamic orthotics work to correctly positioning the limb in a more functional position. This functional position allows for those muscles, tendons and bones to function at their highest potential while increasing stability of the limb. The main differences between rigid and dynamic orthotics is in the material they are made from and the functional movement that they allow. Rigid orthotics, typically made from plastic, or casting, do not allow for movement of the joint unless hinges are specifically added to that orthotic. Dynamic orthotics, typically made from lycra, fit very snug to that joint allowing for movement. There is limited information in
the literature that addresses combining a physical therapy program that incorporates both a modified core strengthening and stabilization program in conjunction with an orthotic wearing schedule of dynamic orthotics. Therefore, the purpose of this study is to examine the benefits of dynamic orthoses (DMO) used in conjunction with a modified core strengthening and stabilization program in order to increase trunk control and grasp control in a 12 year old boy with CP.

Rigid orthotics for the trunk and upper extremities are not as common as for the lower extremities because essential movement is restricted. Since the trunk is responsible for stabilization of the body in all positions and the upper extremity for grasping, it would benefit children with CP to have an orthotic for the trunk and the upper extremities which allows for those movements. Dynamic movement orthoses (DMOs) are made from lycra material that allows for dynamic movement while correctly positioning the limb or trunk in a more natural way that helps to strengthen the muscles. They fit snug to the body and allows those muscles, tendons and bones to function at their highest potential while increasing stability by keeping them in the correct alignment and allow for movement. DMOs can be used to manage abnormal tone while still allowing a child or adult with CP to be functional. DMOs are individually fit and measured for each person. The customized fit allows for increased proprioception. With increased proprioception, the child is able to be more aware of their limb in space and with proper physical therapy interventions can be more functional.

In order for the DMOs to be most effective, patient compliance in the wearing schedule determined by the orthotist is crucial. In addition to the compliance of the patient wearing the DMOs, maintenance of the DMOs is critical. There is a wearing and washing schedule of the DMO that needs to be followed for the best results. DMOs are a newer
approach to treating patients with CP and as a result, there is not a lot of information in the literature studying the benefits of wearing a DMO in conjunction with physical therapy interventions. Clinical research has suggested that wearing dynamic orthoses “reduces tone in spastic and dystonic muscles, decreases involuntary movement and improves axial tone in children with postural hypotonia.” However, research is lacking in examining the benefits of using the DMOs in conjunction with a modified core stabilization program to increase trunk and grasp control in children with the diagnosis of CP.

Other interventions that are used to treat CP are medications and surgical interventions. Medications are created specifically to target increased tone in the muscles and have been used in conjunction with physical therapy interventions to manage muscle tone. Baclofen is a type of muscle relaxer that targets specific hypertonic muscles that have increased tone. Oral baclofen is used to decrease excessive muscle activity of spasticity. In older children, an intrathecal baclofen pump can be surgically inserted into the child’s abdomen. Then a catheter is inserted into the intrathecal space. The concentration of baclofen reaching the cerebrospinal fluid is much greater in the pump than with the oral form of baclofen. Surgical procedures such as tendon transfers, hamstring and heel cord lengthening are in some instances, necessary, however they are more successful when the child is older.

**Case Description**

**Medical History**

The patient is a 12 year old boy diagnosed with spastic CP at birth. He has significant involvement and abnormal tone in all extremities, and core trunk muscles. He currently receives PT through an outpatient program at a hospital. PT services at the hospital are once a week for one hour sessions. This program includes exercises for core stabilization along
with a wearing schedule of DMOs for the trunk and upper extremities. This patient is home schooled and only receives physical and occupational therapy through this hospital. He does not receive any benefits of the public school system.

The patient lives with his mother, father and maternal grandmother who are all extraordinarily dedicated to his care. His family offers him a strong support network and there is excellent compliance with his program at home through the constant assistance of his caregivers. Services are carried over at home on a daily basis for up to an hour by his grandmother. His home program is focused on regular range of motion (ROM) exercises, strengthening exercises for his core and extremities. The main physical therapy goals are to increase core strength to be able to sit independently, minimize tone in his upper extremity and work on grasp control in order to control and manipulate objects.

**Past Surgical History/Medications**

This patient underwent bilateral proximal femoral derotation osteotomies (FDO) of the hips and soft tissue lengthening procedures at age 8. FDO is indicated when it is established that a patient has in-toeing of the legs due to medial femoral torsion that interferes with gait and function. The surgery required 12 weeks of full body cast post-op. Follow up surgery to remove hardware from both hips with additional body cast required for 3 weeks. He was hospitalized at age 10 for an Intrathecal Baclofen Pump (ITB) placement in order to control his pronounced hypertonicity. The ITB pump reduces his tone. His reflex patterns are still present, but less intense. Several months after the ITB placement, he was hospitalized for 10 days for Botox toxicity. The Botox toxicity left him with significant decrease in head and trunk control and a regression in physical skills. This is improving
significantly with daily core strengthening exercises as well as with gradual adjustments of his ITB levels.

**Functional Limitations/ Evaluation**

This patient’s patterns of movement tend to be dominated by reflexes which limit coordinated movement in functional patterns. Due to the nature of the patient’s diagnosis, he has been receiving physical therapy services since he was an infant and is totally dependent in all activities of daily living (ADL) skills.

The three main functional tasks we looked at to determine effectiveness of the core strengthening and stabilization program with DMOs were: 1) sitting on a bench, 2) sitting on a bench while reaching to the floor for a toy, and 3) grasp control of a toy.

Before introducing the core strengthening and stabilization program or the DMOs, the patient was unable to sit independently without trunk support and tended to lean laterally to the left. The patient was unable to sit on a bench and reach for a toy to the ground without maximum assistance. He was able to maintain a grasp on a small toy for 5 seconds before dropping it.

Four weeks after start of the program which included the hand and trunk DMOs as well as the core strengthening exercises, the patient was able to maintain a bench sitting position with bilateral upper extremity support of bar at waist level for 30 seconds with a slight lean to the left and moderate assistance 5 out of 6 tries. He was able to sit on a bench and reach for the toy on the ground holding onto upright bar with left hand with moderate assistance, 4 out of 6 tries. He was also able to maintain a grasp on a small toy for 15 seconds before dropping it.
Eight weeks after the introduction of his program, the patient was able to maintain a bench sitting position with bilateral upper extremity support of bar at waist level for 1½ minutes without assistance and several bouts of loss of balance but able to self correct, 3 out of 6 tries. He was able to sit on a bench and reach for the toy of the ground, holding onto upright bar with left hand with minimum assistance, 4 out of 6 tries. He was also able to maintain a grasp on a medium size toy for 25 seconds before dropping it.

Twelve weeks after introducing the core stabilization and strengthening program as well as the use of his trunk and upper extremity DMOs, the patient was able to maintain a bench sitting position with his hands holding his chest to a bar at waist level for up to 3 min without assistance or loss of balance, 5 out of 6 tries. He is able to sit on a bench and reach for the toy on the ground, holding onto upright bar with left hand with contact guard only, 5 out of 6 tries. He is able to maintain a grasp on a small and medium size toy for 45 seconds without dropping it.

**Assistive and Adaptive Equipment**

The patient wears upper extremity DMOs to help position his hands in functional positions and to keep his thumb web space opened. For his lower extremities he requires rigid ankle foot orthoses (AFO) for weight-bearing and proper alignment. He also wears a trunk DMO for increased support of his core. Before the trunk DMO, this patient used a rigid trunk orthotic to prevent the progression of scoliosis with a wear schedule of up to 6-8 hours per day. He is able to walk with support of a gait trainer over short distances with moderate assistance. The gait trainer is a framed gait device that assists patients in walking safely and efficiently. It has 4 wheels in which a patient is support by straps and is able to then ambulate independently. He uses a free stander for up to 2 hours a day. A free stander is a device
whereby the patient is supported by straps allowing the patient to stand upright for supported weight-bearing to assist in maintaining a standing position. He uses a power wheelchair in which he is independent with joystick controls.

**Diagnosis**

The most appropriate practice pattern for this patient using the Guide to Physical Therapy is Preferred Practice Pattern 5C: Impaired Motor Function and Sensory Integrity Associated With Non-progressive Disorders of the Central Nervous System-Congenital Origin or Acquired Infancy or Childhood.\(^\text{18}\)

**Prognosis**

CP is a non-progressive neuromuscular disorder of posture and movement.\(^\text{1}\) Due to the nature of the disorder, average lifespan of patients with CP, and taking into account the functional progress of the patient, this patient’s prognosis is good when considering the many different presentations of CP, its several classifications and the common co-morbidities.

**Plan of Care**

This patient is consistently being treated by physical therapists through an outpatient program of a hospital once a week for one hour sessions. He is periodically reevaluated and reassessed for new equipment as he is growing. The family’s main goals for this patient are to increase trunk and grasp control in order to increase his functional ability. His short and long term goals are general functional goals for progression of functional abilities and maintenance of the present abilities.
**Intervention**

His physical therapy program includes, stretching, exercises for core stabilization along with a wearing schedule of DMOs for the trunk and upper extremities. His DMO wearing schedule for both the trunk and upper extremity DMOs were for 6-8 hours a day during the day. At every session, the patient receives passive stretching to his bilateral upper and lower extremities, as well as his trunk and core all performed by the treating physical therapist before donning the patient’s DMOs for him. Total stretching takes 15-20 minutes. The rest of the treatment session includes the wearing of the DMOs throughout the session. Assisted gait with proprioceptive, verbal and tactile cueing to progress each foot, making sure not to scissor his gait. The core stabilization exercises include sitting on bolster and reaching in all directions for objects in and outside his base of support and pulling himself up from supine with hand held assistance.

**Outcome measures**

No true standardized assessment for this patient was used. His progress was determined by observational functional changes per report of his treating physical therapists and was recorded in his chart.

**Discussion Section**

A core strengthening and stabilization program in conjunction with a DMO wearing schedule for the trunk and upper extremities have been shown to be effective in improving core strength and grasp control for this 12-year-old boy with CP. The majority of the literature shows improvements as a result of either an intensive physical therapy intervention program or an orthotic wearing intervention program with children with CP. There is
however, limited information on the combination of these two interventions to measure gains in trunk and grasp control.

Based on the available literature, wearing an orthotic made of lycra is most beneficial if the patient has the capacity to perform purposeful movements as well as actively participate in daily activities. When looking at this patient’s pelvic and trunk instabilities, increased muscle tone as well as involuntary movement, wearing the DMOs improved both postural stability and upper limb movement as demonstrated in Table 1. The best results occur when a wearing schedule is followed that does not interfere with the patient’s active participation in daily activities.

Regarding physical therapy interventions for children with CP, children who had specific goals for treatment using a greater intensity throughout their program rather than general aims and a non-intensive program showed greater and quicker motor skills acquisitions. Children who have CP benefit greatly from an intense physical therapy intervention program consisting of strengthening exercises as well as functional activities that meet specific goals set for them by their treating therapist.

From this case report, a 12-year-old child with CP benefited greatly from an intense physical therapy intervention program of a core strengthening and stabilization program as well as a DMO wearing schedule in increasing trunk and grasp control. It is important to note that these gains were made due in large part to the daily carryover program at home and excellent compliance with the wearing schedule of the DMOs. According to Bower, a carryover program at home is critical for the progressive functional development of a patient with CP as compared with patients who have little or no carryover at home.
as compliance of wearing schedule, carry over of interventions at home, as well as motivation of the patient to participate, can all influence how effective this program can be. The improvements the patient made in both trunk and grasp control were noted by his treating physical therapist. The treating physical therapist evaluated the child’s performance with short and long-term goals that were functional and measureable.

There were some limitations to this case report. No true outcome measurement tool for assessment of motor changes over time in children with CP was used. In order to assess the progress of the patient, the treating therapist used objective measures, as well as subjective information reported by caregivers of the patient’s progress. A tool such as the gross motor function measure (GMFM) would give a more standardized way to measure this child’s improvements. The GMFM is validated to evaluate motor changes over time in children with cerebral palsy. Having the outcome measurements be assessed by the treating physical therapist may limit the ability to generalize this treatment program. Every therapist sets different goals for their patients and time for achieving these goals can vary.

There is no “cure” for CP. Therefore, the patient assessed in this case report does not have a discharge date where specific long term goals are met and no more progress can be made. If therapy was to be discontinued, a regression will be apparent as seen by his interruptions in therapy treatment sessions as a result of the patient’s several hospitalizations. Even with only several weeks of no therapy treatment in order to allow the patient to recover for surgery, a regression in the patient’s physical skills were noted by his treating therapists. This patient and his caregivers are committed to working towards continued improved control and strength of his muscles to be the most functional in his activities of daily living.
Future research is needed on the benefits of DMOs with a combined core strengthening and stabilization program. These studies should include a larger sample size using a treatment and control group. The population should not be a sample of convenience, but rather a sample selected from specific inclusion/exclusion criteria. The research should address functional capacity for daily activities using an outcomes measurement tool such as the GMFM either solely or in conjunction with the treating therapist’s objective measurements.

**Conclusion**

Children with spastic CP may benefit from a modified core strengthening and stabilization program in conjunction with a DMO wearing schedule in the following ways; increased strength and stability of the core muscles, increased functional mobility and increased tone management. It was however difficult to determine if the DMOs had a true effect of the patient’s progression of functional activities, strength and ROM gains or if it was the combination of all his treatments, therapy, caregivers and home carryovers that were the most effective for him. DMOs can be costly, difficult to don and doff, as well as time consuming in the development and implementation of the wear and maintenance schedule. Therefore, more research needs to be done on the true effects of DMOs on children with CP as well as their benefits with a combined core strengthening and stabilization program.

This patient did benefit from a modified core strengthening and stabilization program in conjunction with a DMO wearing schedule. He demonstrated improvements in strength and stability of the core muscles for unsupported sitting, increased functional mobility for reaching to the ground, grasp control and increased tone management.
Table 1. Core Strengthening/Stabilization Functional Activities over 12 week period

<table>
<thead>
<tr>
<th>Week</th>
<th>Sitting on a Bench</th>
<th>Sitting on a Bench While Reaching to Floor For a Toy</th>
<th>Grasp Control of Toy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Unable independently; required trunk support leans to the left</td>
<td>Unable independently; Maximum Assist</td>
<td>Able to maintain for 5 seconds before dropping</td>
</tr>
<tr>
<td>4</td>
<td>Able to maintain with bilateral UE support of bar at waist level for 30 seconds with slight lean to the left; Moderate Assistance 5/6 trials</td>
<td>Able to maintain with left UE support of bar at waist level; Moderate Assistance 4/6 trials</td>
<td>Able to maintain for 15 seconds before dropping</td>
</tr>
<tr>
<td>8</td>
<td>Able to maintain without UE support, 1½ minutes without assistance several bouts of loss of balance, able to self correct; 3/6 trials</td>
<td>Able to maintain with left UE support of bar at waist level; Minimum Assistance 4/6 trials</td>
<td>Able to maintain for 25 seconds before dropping</td>
</tr>
<tr>
<td>12</td>
<td>Able to maintain with no UE support, 3 minutes without assistance, no bouts of loss of balance; 5/6 trials</td>
<td>Able to maintain with left UE support of bar at waist level; Contact Guard 5/6 trials</td>
<td>Able to maintain for 45 seconds before dropping</td>
</tr>
</tbody>
</table>


