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Dynamic Core Intervention for a Child with Cerebral Palsy

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Abstract

Purpose: To describe and assess the Dynamic Core for Kids (DC4K) model of intervention that promotes central stability as an alternative to conventional trunk strengthening programs for a child with Cerebral Palsy.

Methods: Weekly physical therapy sessions, over two 8-week periods, based on the DC4K model were provided to a 12-year old boy with moderate hemiparesis. Pre and post-intervention, clinical observational notes, photos, and parental report were examined.

Results & Discussion: Participant's postural alignment and stability, trunk muscle coordination and strength and functional movement ability all showed improvement in sitting and standing. Pediatric physical therapists may consider using the DC4K model when incorporating therapy aimed at core stability as part of their intervention. Further investigation is warranted to assess outcomes of DC4K intervention and core stability in children of different ages and with various motor impairments.

Introduction

Pediatric physical therapists aim to improve the functional ability of children with developmental conditions. Research regarding children with Cerebral Palsy (CP) suggests that trunk alignment and stability are important variables for postural control necessary for function [1,2]. In the adult literature, the concept of 'core stability' as a component of trunk control has been elaborated, studied, applied and found to have a positive impact on clients with varied diagnoses. Kibler and associates [3] described 'core stability' as "the ability to control the position and motion of the trunk over the pelvis and leg to allow optimum production, transfer and control of force and motion to the terminal segment in integrated kinetic chain activities" [p.190]. Optimized 'core' muscular recruitment patterns have been shown to contribute to trunk and pelvic control [4-10]. Incorporating an optimized muscular recruitment pattern to promote trunk and pelvic control ('core stability') within pediatric Physical Therapy (PT) intervention strategies may enhance postural and functional outcomes. Several groups of muscles have been found to be involved in promoting 'core stability. They include the 'inner core' muscles, i.e., the respiratory Diaphragm (RD), Transversus Abdominis (TA), Pelvic Floor (PF), Multifidus (M); and 'outer core' muscles, i.e., the Internal Oblique (IO), External Oblique (EO), Rectus Abdominis (RA), Erector Spinae (ES), Gluteal Muscles (GM), Adductors (ADD) and Latissimus Dorsi (LATS) [4-9,11,12].

The interplay between the components of the inner core unit contributes to 'core stability' by modulating Intra-Abdominal Pressure (IAP) through the cyclical rhythm of the RD. The descent of the RD provides inhalation stability by generating an increase in IAP; the PF and TA muscles lengthen and elastically load in response to the added abdominal pressure. On exhalation, the RD ascends, IAP is reduced and the PF and TA recoil and concentrically engage to provide stabilizing force. Thus a relative balance of IAP and muscular forces is maintained to ensure postural control, trunk and pelvic stability and continence [4,7,8,13-17] and although breath holding is a common strategy among pediatric clients, Massery demonstrated dependence on breath holding diminishes postural support from the RD for standing balance [17].

In addition, the inner core components establish a stable base of anticipatory pelvic and lumbar stability as a foundation for movement [4-6,9,10]. Hodges and colleagues demonstrated the dual capacity of the inner core muscles (RD, PF, and TA) to maintain tonic postural support, as well as to be recruited for discrete bursts to support movement of the upper extremity. However, the outer core muscle groups studied demonstrated a variable, reactive activation pattern dependent on the direction of the movements [4-6]. This finding represents a deep to superficial recruitment pattern

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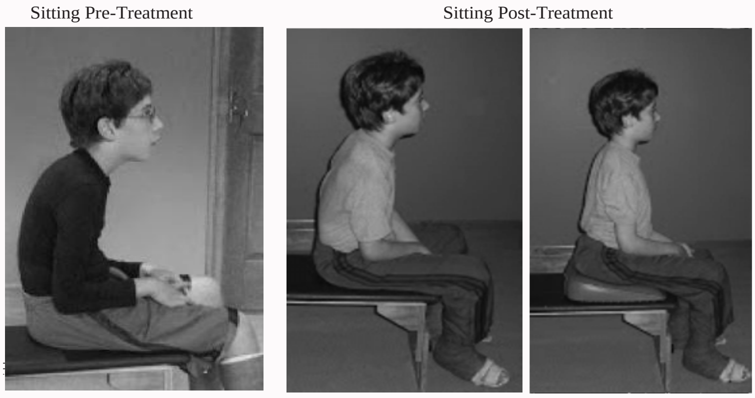

Figure 1A:

Figure 1B:

that provides complementary anticipatory and reactive muscular elements. Muscular recruitment patterning harmonized with the regulation of the IAP system simultaneously stabilizes and remains responsive to the task specific demands of function and movement. Postural alignment has been shown to influence the recruitment of the inner and outer core muscles to support their availability for trunk and pelvic control [18-20].

In the practice of PT for children with developmental conditions, trunk alignment and stability are considered important yet few studies have provided the needed evidence. Cherng and colleagues [1] noted that an increased angle of seat inclination toward anterior pelvic position positively affected postural stability and reaching efficiency of children with spastic CP but did not specify muscles targeted in the protocols. No studies have yet addressed a clinical model for improving core stability function in children with disabilities.

To date, the trunk muscles of children with and without motor disabilities have been primarily investigated as part of studies on Anticipatory Postural Adjustments (APAs). During tasks performed in sitting, variation in neck and trunk muscle activation latencies (EMG activation of *outer core* muscles) have been recorded [22-24]. In standing tasks or perturbations occurring in standing, impairment in muscle timing and increased co-activation has been noted for children with motor challenges [2]. Children with CP were found to generate APAs similar to typical adults and children, although children with diplegia performed at a lesser EMG magnitude and had higher baseline muscle activation [25]. Children with Developmental Coordination Disorder involved in three functional tasks have also shown a later onset of core muscle activity (TA, IO, EO) compared to the control group [26].

Investigators and clinicians have proposed a variety of core stability exercise programs in adults comprised of static or isometric contractions of core components such as isolated TA activation or global trunk muscle bracing aimed at lumbar stabilization. The static ("hold") nature of these contractions does not mimic the dynamic interplay between the inner core and outer musculature and IAP system [4-6]. The purpose of this brief report is to describe the Dynamic Core for Kids (DC4K) model, an alternative approach that seeks to provide dynamic and graded core stability for children during movement transitions, function and play.

Methods

Descriptive case report before and after the delivery of the DC4K intervention, documentation of posture and functional activities was based on clinical observation, photos taken with the instructions to sit or stand, looking straight ahead, and parental report.

Participant

MD was a 12-year old boy, born at 25 weeks gestation weighing 971 grams, diagnosed with moderate right spastic hemiparesis and a seizure disorder controlled with medication. He sat independently at 2 years old and walked at 3 years old. Since the age of 2, MD received

Table 1: Intervention Program for MD.

GOALS 1st 8-week block	INTERVENTION/ HOME PROGRAM
Week 1 in supine: 1. Optimize neutral alignment of rib cage over pelvis 2. Gain full respiratory diaphragm excursion & modify upper chest breathing pattern	1. Use props (pillows, towel rolls) to support neutral range alignment of rib cage over pelvis 2. Practice “umbrella breathing” (360 opening of ribcage with focus on lateral rib cage excursion) - umbrella inhale, exercise on extended exhale -“blow before you go”
Week 2-3 in supine: 1. Link anticipatory inner core activation with outer core activation	Supported in neutral range alignment; umbrella inhale, exercise on extended exhale = “blow before you go” 1.. Practice bridging with LATS pull down/Theraband (=Posterior Oblique Synergist exercise) 2. Hold ball between knees, UE Theraband pull diagonally across trunk (Anterior Oblique Synergist exercise)
Week 4-5, in sitting: 1. Gain neutral rib cage and pelvic alignment 2. Link inner and outer core recruitment against gravity	Sitting in chair with a 2” forward tilt wedge: 1. Posterior Oblique Synergist exercise 2. Anterior Oblique Synergist exercise
Week 6 in sitting: 1. Improve participation of pelvic floor musculature 2. Strengthen mid-range hip rotation control	Repeated exercises from W4-5 seated in chair with a 2” forward tilt wedge and holding ball between knees
Week 7-8, in standing: 1. Use of umbrella breathing to gain neutral alignment control 2. Improve awareness of umbrella breathing and “blow before you go”	Standing with verbal and tactile cues for alignment: 1. POS exercise 2. AOS exercise
GOALS 2nd 8-week block	**INTERVENTION/ HOME PROGRAM**
Week 1 in sitting and standing: Review Block 1 exercises	1. “Umbrella breathing” 2. Posterior Oblique Synergist exercise 3. Anterior Oblique Synergist exercise
Week 2 in sitting: 1. Increase GM activation linked with LATS 2. Develop transition from sitting to standing	Sitting with 2” forward tilting wedge: 1. POS exercise progressively increasing seat height at 110, 130 and 150 degrees of hip flexion
Week 3 in standing: 1. Maintain neutral range alignment during activities 2. Increase challenge of activities	1. “Umbrella breathing”, exercises Block 1, Week 7-8 2. Full upright standing against wall, repeat all previous exercises
Week 4, in standing and walking: 1. Optimize alignment in gait 2. Advance challenge to core and postural musculature	Walking: 1. Standing without support, Posterior Oblique and Anterior Oblique Synergist exercises 2. “Push though gait cycle”
Week 5-6, in parallel & stride standing: 1. Increase neutral range rib cage and pelvic alignment 2. Reinforce postural muscle system	1. Umbrella breathing, verbal and tactile cues for alignment 2. Posterior Oblique and Anterior Oblique Synergist exercises
Week 7-8, in combination: 1. Maintain alignment in standing and gait 2. Increase activation of abdominals in gait	1. Sit to stand: Posterior Oblique Synergist exercise 2. Standing: independently maintain neutral range rib cage alignment 3. Gait: “push through the gait cycle”

ongoing PT and Occupational Therapy (OT) focused primarily on functional transitional movement and gait training, and awareness and gross grasp for bilateral hand activities. Modifications of his educational curriculum were made when he displayed decreased information processing speed and difficulty with abstract concept development. He was attending his neighborhood school in a combination of mainstream and individual needs classes at the grade 6 level.

At the time of DC4K intervention, MD was assessed on the Gross Motor Functional Classification System [27] at level 2. In sitting, MD’s posture displayed a moderate posterior pelvic tilt, lumbar and thoracic flexion, with forward head posture and upward eye gaze, and right hip in external rotation and abduction. He could remain seated for up to 10 minutes after which he requested to change his sitting position, regardless of supports used. He consistently used upper extremity support to complete a sit-to-stand transition, which required effort. He maintained static standing a maximum of 3 seconds and then needed to take steps to keep his balance. In standing (with orthotics) he maintained an anterior pelvic tilt, lumbar extension, thoracic flexion, forward head posture, right posterior trunk rotation, and pelvic retraction with asymmetrical weight bearing through lower extremities, i.e., increased on left side (Figure 1).

During gait, MD showed compensatory right trunk and pelvic retraction, right lateral trunk flexion in the stance phase, decreased right stance phase, and reduced right push off. He walked independently on all terrain, rode an adapted bicycle, and participated in an adapted skating program for recreation. Activities occurred at a slow speed and he showed signs of early fatigue. He tended to hold his breath during transitional movements as well as in preparation for more challenging motor tasks, presumably as a means to gain trunk stability.

Ongoing parental concerns were his kyphotic sitting posture and asymmetrical standing posture as well as the increased frequency of falls during recreational activities over the previous summer. His parent’s goals in PT included continued focus on improved posture and endurance in sitting for schoolwork, and improved posture and balance in standing.

Intervention

MD participated in weekly, I hour, PT sessions over two 8-week blocks, 3 weeks apart. The goals of the first 8-week block were to: a) increase trunk muscle coordination, strength, and stability for a prolonged postural task such as maintaining bench sitting for 20 min in classroom; and, b) increase dynamic postural stability in the functional movement task sit-to-stand without the use of arms, and then while carrying school materials. Concurrent with the first block of intervention, MD underwent bilateral lower extremity serial casting (R1 and R2 ankle ROM gains, based on Cusick’s [28] method, were minimal). The goals of the second 8-week block were to further the previous goals in more demanding positions and tasks against gravity, e.g., standing in a more neutral range alignment with ribs over pelvis and with reduced reliance on extreme anterior tilt, and the functional ability to maintain quiet standing for 30 sec to facilitate safety and social interaction. The DC4K intervention for MD is described in Table 1.

Results and Discussion

Over the first 8-week block, MD's improved his postural alignment, trunk muscle strength and coordination to maintain sitting with and without the use of a wedge cushion at school and at home, i.e., sitting with neutral range rib cage and pelvis for 20 min (Figure 1A). He also achieved the functional ability to transition from sitting to standing without arm support, during his daily activities.

Following the second 8-week block, MD's postural alignment in standing had substantially improved: standing with decreased anterior tilt of his pelvis and increased neutral range rib cage alignment (Figure 1B). He was able to achieve the function of quiet standing up to 60 sec without loss of balance. His parents also reported a decreased incidence of falls when playing.

This report described the first application of the therapeutic program DC4K, specifically aimed at developing 'core stability' for children following the initial work on core function in pediatrics by Kane and Barden [26]. In the DC4K model, access to the IAP system was considered a key factor and was obtained via the working relationship among the RD, TA, and PF musculature. The interaction of the inner core components to contribute to the IAP based stability cycle hinges on the action of the RD [4,5,14-16]. Thus, creating enhanced breath patterns to capitalize on this interaction and provides an attainable access point for enhancing postural control and 'core stability' in the pediatric population. In this case, a change in breathing pattern was achieved first through lateral movement of the ribcage to optimize excursion of the RD on inhalation ('umbrella breaths'). This practice was followed by exhalation prior to movement, using the "blow before you go" verbal cue, tactile cueing and blow toys. Full excursion of the RD on inhalation was intended to optimize trunk stability through increasing IAP and to ensure elastic loading of the PF and TA muscles to prepare for concentric activation on exhalation. Thus improving both inhalation stability through IAP increase, and exhalation stability via active inner core muscular participation [4-8,10,14-16]. Harnessing of the IAP stability system was coupled with the anticipatory role of the inner core via the "blow before you go" cue. This practice optimized exhalation activation of the PF and TA as a preparatory anchor for functional movement and elicited an inner to outer core muscular recruitment pattern supported by the adult literature [4-6,10].

The DC4K program emphasis on postural alignment of the pelvis and ribcage in the neutral range was a critical feature aimed at enhancing the IAP system and inner core component availability for recruitment, and likely contributed to positive therapy outcomes. It is probable that repetition also contributed to embedding this neuromuscular pattern and maintaining improvements. The treatment progression built the inner core component interaction first, as a foundational support for the rest of the postural system.

Moving MD into more upright, anti-gravity positions and then into functional activities and gait gradually provided increased challenge. Thus a neuromuscular strategy for midrange trunk control in anti-gravity positions and in dynamic function was built that promoted postural stability and control within daily tasks, transitions, functional movements and play. The pattern of inner to outer core muscle recruitment explored in the adult research was found to be applicable to a 12-year old child with a moderate motor impairment.

The report of a DC4K intervention with one child presents inherent limitations. Each child has unique characteristics and abilities; the results from this case may not be generalized. Observations documented from the treating therapist are an important aspect of clinical assessment and an integral part of evidence-based practice. Outcomes would need to be further supported by standardized outcome measures over time such as the Gross Motor Function Measure, Pediatric Balance Scale, or Timed Up and Go. Photos are a useful clinical means to document changes but represent a 'moment' rather than a conclusive demonstration of sustained performance; videotaping and quantitative measures of alignment would be beneficial. Maintenance of functional changes once treatment has ceased provides information regarding the effectiveness of intervention. Repeating these outcome measures post-intervention would provide important information regarding the ability of the intervention to create permanent functional change. MD also received an 8-week series of bilateral lower extremity casting; the small change in ankle ROM may have enhanced his capacity to respond to alignment cueing in standing which promoted the muscular availability needed for postural control.

This report on a case study provided initial descriptive findings on the DC4K model and the potential benefit from the implementation of an intervention targeting dynamic coordination of inner and outer core muscles for improved core stability. Further investigations are warranted to explore core function in children of different ages and motor impairments, and to measure physiological and functional outcomes from using exercise programs based on the DC4K model.

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