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Trunk control and gross motor outcomes after body weight supported treadmill training in young children with severe cerebral palsy: a non-experimental case series

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Abstract

Objective: To explore the impact of a body weight supported treadmill training (BWSTT) intervention on postural control and gross motor function in three young children with cerebral palsy (CP) classified as Gross Motor Function Classification System (GMFCS) levels IV or V.

Method: Children (N = 3) between the ages of 2 to 3 years who were diagnosed with CP classified as GMFCS levels IV and V participated in BWSTT three times per week. The Segmental Assessment of Trunk Control (SATCo) and the Gross Motor Function Measure (GMFM-66) were assessed before and after the six-week intervention.

Results: Final testing revealed that all participants improved on the SATCo and GMFM.

Conclusion: BWSTT is a viable intervention that may improve trunk control and gross motor outcomes in young children with severe CP. Further research is needed to explore the impact of BWSTT for young children classified as GMFCS levels IV and V.

Introduction

Cerebral palsy (CP) is a group of permanent disorders of posture and movement resulting from trauma to the fetal or infant brain. Children with CP can be classified using the Gross Motor Function Classification System (GMFCS), which consists of five levels based on gross motor functional ability [1,2]. The lower numerals represent higher function.

The natural progression of gross motor function has been described by Rosenbaum et al. [3] by plotting the Gross Motor Function Measure (GMFM) scores for children with CP, resulting in prognostic GMFCS curves. The curves demonstrate a peak and plateau in motor skills by seven years of age across all five GMFCS levels of CP [3]. Children classified as GMFCS levels IV and V make up approximately 25 to 35% of all children with CP [1]. The GMFCS curves indicate that

90% of motor potential is reached before 4 years of age for children with CP classified as GMFCS level IV and V [3]. Therefore, the toddler years are a critical time for impacting motor outcomes.

Using The World Health Organization's *International Classification of Functioning, Disability and Health* (ICF) as a framework, studies have shown that rehabilitation professionals should provide interventions with increased intensity at the ICF level in which they hope to impact for children with severe CP. may be beneficial for improving function. [4-6] Body weight supported treadmill training (BWSTT) is a task-specific intervention that uses a harness to reduce the child's body weight, with trained assistants facilitating reciprocal movement of the child's legs. BWSTT offers increased intensity for young children with severe CP and may influence functional mobility.

Published studies demonstrate that BWSTT can improve walking ability, endurance, and speed for ambulatory children with CP [7-10], and accelerated walking skills and increased gross motor function in infants and toddlers with CP [11,12]. BWSTT can also improve overall gross motor function in non-ambulatory school-aged children with CP classified as GMFCS levels IV and V [13,14]. In systematic reviews, authors have concluded that treadmill training for children with CP is more beneficial for those who show more severe walking disability, but further research is needed to address whether BWSTT has a general effect on gross motor development in young children [15,16]. The purpose of this study was to explore the impact of a six-week BWSTT program on trunk control and gross motor function in young children with CP classified as GMFCS levels IV and V.

Methods

Three children with CP were recruited from local rehabilitation clinics. All parents signed an informed consent. Children were included if they had a diagnosis of CP classified as GMFCS

level IV or V and were between the ages of one to four years old. Children were excluded from the study if they had any secondary conditions unrelated to CP or any in-dwelling tubes or lines that would interfere with the harness system. They continued with their usual physical therapy during the intervention. Characteristics of the participants are summarized in Table 1.

Child 1 was a three-year-old boy (GMFCS level V) who displayed hypotonicity of the trunk and neck, with spasticity in all four extremities. He required a head support and bilateral ankle-foot orthoses during treadmill training. He was dependent for all functional movement.

Child 2 was a two-year-old boy (GMFCS level IV) who displayed a kyphotic posture, decreased antigravity trunk control, spasticity in both lower extremities, and mild hypertonicity in his upper extremities. He was able to belly crawl for mobility in his home but was unable to stand independently. Spasticity of his lower extremities caused him to walk on his toes with excessive hip adduction ('scissoring') up to 10 feet with assistance.

Child 3 was a three-year-old girl (GMFCS level IV) who had spasticity limiting movements in both lower extremities and her left upper extremity. She was able to belly crawl around her house but was unable to stand without assistance. She walked short distances with assistance and lower extremity scissoring.

A physical therapist (PT) with 13 years of experience and a board certification as a clinical specialist in pediatric physical therapy assessed each child during one session, performed the week before and the week after the BWSTT intervention. Outcome measures included the Segmental Assessment of Trunk Control (SATCo) and the Gross Motor Function Measure (GMFM-66).

The SATCo is a 20-item scale that assesses static, active, and reactive control of the trunk at seven discrete levels [17]. To administer the SATCo, the child sits on a bench with the pelvis secured in neutral alignment. The examiner provides trunk support starting at the shoulder girdle,

moving segmentally down the child's trunk. For each item, the examiner gives the child a score of present, absent, or not tested, with the highest possible score of 20. Greater trunk control is represented by the higher levels, up to Level 7. Intrarater and interrater reliability for the SATCo is high (ICC = 0.98, ICC = 0.84, respectively) [17]. Concurrent validity was established with the sitting sections of the GMFM the Alberta Infant Motor Scale [17].

The GMFM-66 is a measure of gross motor function for children with CP [18]. The examiner scores a child's capabilities across five dimensions of functional movement: A) Lying and Rolling, B) Sitting, C) Crawling and Kneeling, D) Standing, and E) Walking, Running, and Jumping. The child receives a score of 0 (does not initiate) to 3 (completes). The GMFM-66 has strong test-retest reliability (ICC = 0.967 to 0.99) and interrater reliability (ICC = 0.978) for children zero to three years old, with construct and content validity supported in children with CP [18, 19].

Each child was fitted with a MAGS Suspension Vest pediatric harness (Maine Anti-Gravity Systems Inc, Portland, Maine). The harness was connected to an overhead SafeGait 360° Balance and Mobility System (Gorbel Medical, Victor, New York), which allows a minimum of 10 pounds to be off-loaded, up to a maximum of 50% body weight support. Ambulation occurred on a Gaitkeeper GK 2000T treadmill (LiteGait by Mobility Research, Tempe, Arizona).

A PT trained in pediatric locomotor training led BWSTT sessions. Graduate students assisted the PT in facilitating the gait cycle and decreased assistance as the child exhibited control; however, no children had the ability to ambulate without facilitation from the assistants for proper gait kinematics.

Children participated in BWSTT three days per week for six weeks. Initially, 50% body weight was off-loaded for each child and systematically decreased to the lowest amount allowed

(10 pounds), representing a different percentage for each child based on weight. Starting treadmill speed varied from 0.4 to 0.8 miles per hour (mph) and increased to a maximum range of 1.2 to 1.9 mph. Table 2 summarizes the BWSTT parameters. Children were encouraged to walk for as long as possible in bouts of five to eight minutes, with short standing breaks as needed. Figure 1 depicts a typical standing break of Child 3. Figure 2 shows a walking bout.

This case-series used a one-group pretest-posttest non-experimental design. GMFM-66 scores were entered into the Gross Motor Ability Estimator computer program, which provides an interval scale score and the standard error. The GMFM-66 change scores that occurred after the BWSTT intervention were compared to the expected natural progression of gross motor function for children with CP using the GMFM Evolution Ratio [21]. A ratio greater than one indicates the measured change was more than what would be expected.

Results and Discussion

The pretest and posttest scores for each child are presented in Table 3. Final scores revealed that all three children improved in their gross motor function and trunk control. Child 1's increased SATCo score indicated improved head control. The other two children showed improvements in trunk control. The GMFM Evolution Ratio was calculated for the participants; however, the ratio for Child 1 was unable to be calculated since his expected change was 0. The actual change scores and the expected change scores for each child are presented in Table 4.

The main objective of this case series was to explore the gross motor function and trunk control outcomes of a six-week BWSTT intervention for three young children with severe CP. Average attendance during the six weeks was 94.4%. All three children improved in their gross motor function beyond what would be expected through natural progression [21]. According to Curtis et al. [22], segmental trunk control appears to be an important factor determining the gross

motor function in children with CP. We speculate that this anti-gravity effort of the postural muscles during BWSTT, even while wearing the harness may have contributed to gains in trunk control, which in turn may have led to improvement in gross motor function.

Child 1 started with only the ability to hold his head up statically for five seconds requiring a head support BWSTT. His mother commented that the biggest change she saw after BWSTT was his ability to hold his head up and look around the room. She also reported he had increased motivation to walk using a gait trainer in therapy sessions.

The mothers of Children 2 and 3 commented separately that their children were walking more in their usual physical therapy sessions, both indicating a desire to be upright. During gait training with the home PT, the mother of Child 3 noticed her daughter had less ‘crisscrossing’ of her legs. The mother of Child 2 reported having an easier time carrying him throughout the house because he was not leaning on her as much as he did prior to the intervention.

We chose the six-week time frame based upon previous literature [9,10] and used the predictive natural evolution curves developed by Marois et al. [21] in an attempt to control for maturation [23]. A longer time frame may have yielded greater improvements in outcome measures, and the mothers of all three children expressed the desire to continue the program because of the positive results they noticed at home.

This case series lacks the control of a more rigorous research study; therefore, the results may have alternative explanations beyond the BWSTT intervention and are not generalizable. The participants continued their usual therapies and regular anti-spasticity regimens throughout the study, which could have impacted the results. Factors varied between the three children, based on their tolerance, physical ability, and motivation during BWSTT, including the use of orthoses, length of time walking, treadmill speed, and body weight support.

The 10-pound minimum weight off loaded required by the overhead system was a limitation in this study. If a smaller amount could have been off loaded, the children would have increased their lower extremity weight bearing, resulting in more antigravity postural muscle effort, and possibly greater improvements in trunk control.

The results from this case series are encouraging. However, future research is needed to determine if BWSTT can improve function across a larger population of young children with severe CP. Although a randomized controlled trial could be ideal, the age of the children and severity of CP may limit the feasibility of such a study. Researchers might consider using a single subject research design, such as a concurrent multiple-baseline design across participants [24] and include follow-up testing to examine long-term effects. Additionally, the potential mechanisms that contributed to improved trunk control despite the trunk support of the harness need to be further examined.

In conclusion, three young children with CP classified as GMFCS levels IV and V improved in their trunk control and gross motor function after 16 to 18 sessions of BWSTT. These positive changes support the use of BWSTT in toddlers with severe CP. Additional studies are needed to explore the long-term effects of BWSTT in young children with severe CP.

Declaration of Interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this paper.

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Table 1: Participant characteristics

Participant	Age during pretest	Gender	Race/ Ethnicity	GMFCS Level	CP Distribution
Child 1	3.3 years	Male	White	V	Spastic quadriplegia
Child 2	2.1 years	Male	Hispanic	IV	Spastic diplegia
Child 3	3.4 years	Female	Asian	IV	Spastic triplegia

Table 2: BWSTT session details for each participant

	Total Number of Sessions Completed (% Attendance)	Average Total Time Spent Walking on Treadmill per Session in minutes: seconds (Range)	Average Treadmill Speed in miles per hour (Range)	Average Body Weight Support in percent off-loaded	Average Time Spent Standing per Session in minutes: seconds (Range)
Child 1	17 (94.44%)	18:54 (11:18 – 25:54)	1.52 (0.7 – 1.9)	35%	9:41 (4:25 – 16:56)
Child 2	18 (100%)	21:00 (10:32 – 26:24)	0.97 (0.6 – 1.2)	46%	7:16 (3:01 – 12:43)
Child 3	16 (88.89%)	20:18 (4:26 – 27:00)	0.94 (0.4 – 1.2)	44%	8:26 (5:56 – 18:06)

*Normal gait speed for a typically developing three year old child is approximately 2.3mph [20]

Table 3: Results of pretest and posttest outcome measures

		GMFM-66 Score (SE) 95% CI	SATCo Total score (Level of control)
Child 1	Pretest	20.5 (2.2) 95% CI: 16.3 – 24.8	1/20 (Level 0)
	Posttest	26 (2) 95% CI: 22.1 – 29.9	2/20 (Level 1)
Child 2	Pretest	36.8 (1.5) 95% CI: 33.9 – 39.7	6/20 (Level 2)
	Posttest	42.4 (1.1) 95% CI: 40.3 – 44.6	11/20 (Level 3)
Child 3	Pretest	31.8 (1.9) 95% CI: 28.1 – 35.5	7/20 (Level 2)
	Posttest	40.9 (1.2) 95% CI: 38.6 – 43.2	13/20 (Level 4)

GMFM-66= Gross Motor Function Measure-66
 SATCo= Segmental Assessment of Trunk Control

Table 4: GMFM-66 change scores using expected natural progression*

	Actual Change after BWSTT	Expected Change with Natural Progression	Gross Motor Function Evolution Ratio
Child 1	5.5	0	Unable to calculate
Child 2	5.6	1.3	3.85
Child 3	9.1	0.33	27.27

*As predicted by Marois et al. [21]

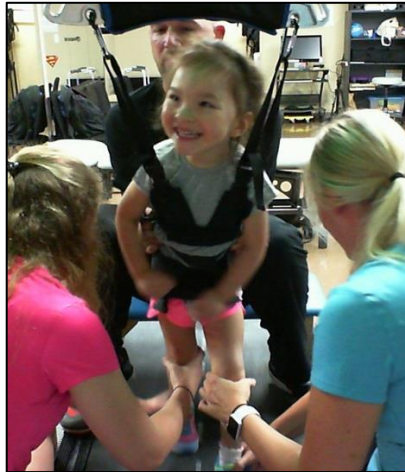
Figure 1



Figure 2



A



B