CASE REPORT

Use of a dynamic gait trainer for a child with thoracic level spinal cord injury

Wendy Altizer,[1] Garey Noritz,[2] Ginny Paleg[3]

[1]Milestones Physical Therapy, Inc., Hurricane, West Virginia, USA
[2]Department of Pediatrics, Nationwide Children's Hospital, Columbus, Ohio, USA
[3]Montgomery County Infants and Toddlers Program, Rockville, Maryland, USA

Correspondence to
Dr Garey Noritz,
garey.noritz@nationwidechildrens.org

Accepted 2 October 2017

To cite: Altizer W, Noritz G, Paleg G. *BMJ Case Rep* Published Online First: [*please include* Day Month Year]. doi:10.1136/bcr-2017-220756

SUMMARY

Paediatric spinal cord injury (SCI) can result in permanent mobility impairment with consequences for activity, participation and quality of life. This case documents the effect of an overground supported stepping intervention using a dynamic gait trainer. To our knowledge, there are no published studies on this intervention for children with SCI and similar interventions have only been reported in children at American Spinal Injury Association Impairment Scale (AIS) levels B and C.

A child with a T10 (thoracic level, vertebra 10), AIS level A injury, sustained at 2 years of age, continued to make gains in all areas including participation, activity, body structure and function over the following 4 years. Use of a dynamic gait trainer improved the participant's ability to be active and participate despite lack of further neuromuscular recovery. This novel approach with a commonly available device allowed the child to be active and participate in the absence of neural recovery.

BACKGROUND

Paediatric spinal cord injury (SCI) occurs rarely, with an estimated frequency of 2 per 100 000.[1] One per cent of all SCI occur in children, with 1450 new cases occurring per year.[2] Children who sustain SCIs are often classified with the American Spinal Injury Association Impairment Scale (AIS). This scale uses a combination of sensory and motor function. The neurological level is that segment most distal with retained sensory and motor function.

Children with a complete injury (no sensory or motor function preserved below the level of lesion) are rated at level A, and are not expected to regain function more than 6 months after the injury.[3] Typical rehabilitation consists of family education regarding skin care, transfers and bowel and bladder care.

Secondary sequelae include hip dislocation/subluxation at a rate of 93%[4] and scoliosis at a rate of 46%–98%[5] or as high as 100%.[6] The incidence of contracture in major joints 1 year after spinal cord injury in children has not been studied, and has been reported in adults to range from 11%–43%.[7] Children who sustain complete injuries at the T10 (thoracic level, vertebra 10) level do not have active hip flexion, and are not predicted to regain the ability to take steps.

Behrman[8] has suggested that intensive body weight support treadmill training with simultaneous facilitation from three highly trained clinicians can improve outcomes for children with SCI AIS levels B and C. This intervention was not feasible for the participant due to the unavailability of this intervention (either equipment or trained therapists) within 150 miles of her home. However, she had access to bracing and a dynamic gait trainer both in her home and at the local therapy clinic. Gait trainers are body weight support mobility assistive devices that are designed to go overground and be used during natural routines and environments. They have been shown to be effective to increase walking distance, number of steps taken, improve mobility level and bowel function, and there was an association between increased intervention time and bone mineral density.[9] The use of a dynamic gait trainer is a novel intervention, and this case is the first to document use of a gait trainer for a child with SCI. The participant's and her family's goals were to improve bowel function and increase participation in dance in the upright (not sitting) position. The family understood that the participant's motor and neural function would not be affected by the intervention, and that the assistive technology was an environmental factor that enabled her to accomplish her goals. The family consented to review the medical records and publication of this report.

CASE PRESENTATION

The participant was a typically developing 23-month-old when she sustained a traumatic thoracic level (T10) SCI due to a falling object. She was transferred to a paediatric trauma centre where the injury was assessed as 'complete' and AIS A. Immediately after the injury, she underwent emergency surgery to remove her damaged spleen and ligate the left renal artery (due to haemorrhage, rendering the kidney non-functional). She also sustained injury to her liver and right kidney. She was intubated and received ventilator support for 5 days. She remained an inpatient for 33 days and was discharged to home in a total body cast to stabilise her spinal fracture. She did not receive any medication that would have been expected to affect her neuromuscular recovery, nor medication to lessen spasticity. The body cast was removed a month after discharge, and she was cleared to participate in an outpatient clinic-based rehabilitation programme in her rural town. One month after her body cast removal, she sustained a right femoral fracture and was placed in a long leg cast for 4 weeks and her therapies were placed on hold. This fracture occurred as she was lying on a changing table, when she purposely 'threw' her legs against the edge of the table because she was 'mad at them'.

Figure 1 The participant at the ballet barre.

INVESTIGATIONS

The Paediatric Evaluation of Disability Inventory (PEDI), Developmental Profile (DP-3), Canadian Occupational Performance Measure (COPM), 6 min walk test, Support Walker Assessment Ambulation Performance Scale (SWAPS) and Spinal Cord Injury Measure (SCIM) were performed at 3 years, 4-½ and 6 years of age and scored using video and parent interview. It must be noted that the SCIM is designed for children age 13 and older, and so is used here despite not being validated in this age group. Missing data were collected by retrospective chart review and considered valid when gathered within 8 weeks of age stated. Details about the injury were collected from the trauma centre where she was treated. All results were phrased within the International Classification of Function (ICF) SCI Core Set. The participant and her family gave written permission for the publication of this report.

DIFFERENTIAL DIAGNOSIS

SCI T10 AIS A

INTERVENTION

On discharge from the hospital, the West Virginia Early Intervention programme loaned the family a manual wheelchair with contoured cushion and back to facilitate upright sitting tolerance. Once her femoral fracture healed, she returned to early intervention at home once per week and clinic-based rehabilitation 4 days per week. The clinic-based therapy focused on range of motion, strengthening, endurance and skin care. The use of a prone self-propelled mobile stander was introduced when she was 26 months old, and was used for 60–90 min daily to improve bone mineral density and range of motion.[10] The participant was provided with a manual wheelchair and an adapted bicycle, and began pool therapy.

Six months after her injury, at age 30 months, her hospital-based medical team recommended against the use of Hip-knee-ankle-foot orthoses (HKAFOs) for standing and supported gait because she continued to present as a T10 and AIS A, and stepping was not seen as a predicted outcome. However, the community-based team ordered HKAFOs and progressed to standing with braces locked at the hip and knee in a reverse walker and parallel bars. The community-based team reasoned that the benefits of standing and walking as well as increasing participation in preferred activities outweighed the cost and burden of the HKAFOs. With the HKAFOs locked in extension at the knee, the participant progressed to using a posterior walker. Initially, she was dependent for all stepping (maximum assistance—the therapist needed to initiate and complete weight shift and stepping) with the participant reporting pain and fatigue. To keep her engaged and to reduce pain and fatigue, a dynamic gait trainer with trunk and pelvic support was introduced at 33 months. A dynamic gait trainer was selected over a static model to afford consistent body weight support.

In the dynamic gait trainer, she was able to have her hands free, stay on her feet for up to an hour at a time, and move well enough to participate in dance class (figure 1). Two months later, she participated in her first dance recital, upright in the standing position, using her dynamic gait trainer. She was able to turn, step and lead her group through the routine, on stage, in front of an audience of over 200 people. A year and a half later, she no longer needed the trunk support, and this was removed from the gait trainer (pelvis support remained). She continued gait training in a posterior walker during therapy, and used the dynamic gait trainer at home and in the community (see online Supplementary video).

Over the next year (to age 52 months), she progressed to stepping reciprocally in her dynamic gait trainer for 40 yards in 6 min as well as participating in hour-long dance classes. At age 6, she was able to walk indoors for moderate distances (100 yards) with moderate speed (1–1.5 mph) in a posterior walker with HKAFO and locked knees and floor reaction fixed ankles components. The participant was able to walk (with assistance at corners for turning) using her HKAFOs and the reverse walker during therapy sessions. Her ability to take steps in the walker with HKAFOs progressed so that she was able to walk 5 days a week at school as she moved between classrooms. She alternated between using her manual chair and power chair for community distances. She continued to use her dynamic gait trainer (now the larger model) with the pelvic prompt for dance.

The gait trainer underwent custom revision by the manufacturer to accommodate the width and weight of the HKAFO. The participant used her manual and power chairs for primary mobility. She was fully included at school with classroom modifications for her to be able to use her power and manual wheelchairs as well as her mobile stander (eg, moving classroom to first floor and moving furniture to create larger empty spaces). She continued to use her dynamic gait trainer during community-based dance classes with typical peers. In church and the community, she was independent for mobility using a combination of devices (power and manual chair, walker, gait trainer, mobile prone stander, adapted power ride on toy). A favourite activity was getting out of her accessible van in her power chair and racing up the 'dirt road' with her friends.

There were no identifiable adverse reactions to her use of a dynamic gait trainer, but caution was needed where the device interfaced with the HKAFO (risk of skin pinching). She did outgrow her first unit, and the second unit was customised to better interface with the HKAFO system.

Her dosage of physical therapy was once a week at home through early intervention up until the age of 3. In addition, she received outpatient therapy at the local clinic four times a week for the first year after injury, twice a week through year 2 and once a week for the following period for 60 min sessions.

OUTCOME AND FOLLOW-UP

Livingstone[11] identified 12 clinical assessments and seven measurement tools that could be used for children using gait trainers. The PEDI rated highest across all areas. This assessment tool measures abilities in the three functional domains of daily activities, mobility and social/cognitive skills. It has established

Table 1 Outcome measures

	Age/36 months	Age/54 months	Age/72 months
SCIM	4+11+4=19	7+13+11=31	11+18+14=43
GMFM-66	38.7	41.8	42.2
PEDI Mobility Domain (Part I)	10	16 (60% increase)	28 (75% increase)
PEDI Self-Care Domain (Part I)	25	35	40
PEDI Caregiver Assistance (Part II)	Self-Care Domain 14 Mobility Domain 9	Self-Care Domain 19 Mobility Domain 13	Self-Care Domain 22 Mobility Domain 15
DP-3 Communication Score	17 34 months	23 53 months	27 71months
DP-3 Cognitive Score	17 31 months	25 53 months	32 83 months
DP-3 Social Emotional Score	15 25 months	22 46 months	31 78 months
DP-3 Adaptive Score	12 20 months	16 29 months	22 46 months
DP-3 Physical Scale	4 6 months	12 19 months	18 30 months
SWAPS (locked HKAFOs and posterior walker)	A=0 B=0 C=0 D=0 Total=0	A=0 B=13% C=13% D=0 Total=6.5%	A=13% B=67% C=13% D=33% Total=31.5%
6 min walk test (HKAFOs and posterior walker)	0 ft	20 ft	150 ft

DP-3, Developmental Profile; GMFM, Gross Motor Function Measure; HKAFOs, hip-knee-ankle-foot orthoses; PEDI, Paediatric Evaluation of Disability Inventory; SCIM, Spinal Cord Injury Measure; SWAPS, Support Walker Assessment Ambulation Performance Scale.

validity and reliability for children, but not specifically children with SCI. The minimal clinically important change on the PEDI has been shown to be 6–15 points or 11%.[12] The participant improved by 6 points (60%) from age 36 to 54 months and 18 points (75%) from age 54 to 72 months.

The Gross Motor Function Measure (GMFM) was used to measure her gross motor skills. The GMFM has not been validated on children with SCI, but is useful to show that without braces or assistive devices, her progress was minimal over the 3 years of intervention.

The Spinal Cord Independence Measure (SCIM) assesses activities of daily living, coordination, eating, functional mobility and continence. It was designed specifically for persons with SCI and has been shown to be valid and reliable for adults and children over the age of 13 years.[13] An adult with an injury at T10 has a median score of 63. The subject's score was well below this median and this may be a result of her age, or because she was a complete T10 and 63 is the median for all T10 injuries. Minimal detectable or meaningful change has not been established for this tool. The participant continued to make gains on the SCIM, most likely due to improved mobility and normal development.

The DP-3 is a screening tool for children with developmental delays. There are five areas which all have norm-based standard scores, percentiles, stanines, age equivalents and descriptive ranges. The DP-3 demonstrated age equivalencies of 6 months, 19 months and 30 months in the physical score in comparison to 31 months, 53 months and 83 months in cognition score. This demonstrates a continued motor deficit in comparison to age but also demonstrates progress in physical skills. The participant's continued gain may be attributed to participation in daily routines using her mobility devices.

The SWAPS is a scale to measure how much support a child needs from an adult to take steps. Validity, reliability and minimum meaningful clinical change have not been established.

The participant's score improved dramatically, showing that even though she was years past injury, she continued to make gains.

The 6 min walk test has been shown to be valid and reliable in children with a variety of mobility impairments, with references for the adult SCI population.[14] The participant's improvement between age 54 and 72 months was double the expected change documented in the literature for her age and level of SCI (median change in the literature 16.5 m/54 ft).

The COPM was administered using the ICF SCI Core set at age 7.

The ICF SCI Core set was developed to comprehensively describe functioning and disability of individuals with SCI.

Defecation (B525) was her primary area of impairment; participant and her family reported that the bowel care programme was much more lengthy, difficult and non-productive when she had not 'walked' for 3 days in a row, for at least 20 min each day. The family also perceived benefits of dance on respiratory function (B440), with improved endurance with higher consistent activity levels.

The participant's results are shown in table 1.

DISCUSSION

In over 4 years of treatment, a child with a traumatic SCI (T10 AIS A) made functional mobility gains as well as age expected gains in all other areas. While a child with SCI would be expected to continue to improve in cognition and adaptive skills due to maturity, her ambulation skills were not expected to improve. Although she regained some active left hip flexion while in her brace system, she remained flaccid without active movement or sensation below her knees. Continued overground training with a dynamic gait trainer afforded her activity, participation and an additional mode of independent mobility, although her primary means of independent mobility was her power chair. Although contractures commonly develop in the first year after SCI,[7] the participant in this case study did not develop contractures during the study period.

Standing has been shown to decrease pain with defecation in children with cerebral palsy[15] as well as increase regularity and decrease bowel care time in adults with SCI.[9] It follows that standing, stepping or walking could positively affect bowel function children SCI. The participant in this case reported easier elimination with daily upright activity.

Children with SCI are predicted to make motor gains based on their AIS score, level of lesion and completeness of lesion. Most professionals believe that after the first 6–12 months, recovery potential for ambulation is maximised, especially in injuries with complete lesions. Researchers[8 16] have suggested that aggressive treadmill training with body weight support can enhance motor recovery following SCI for incomplete lesions only. This therapy is intensive, requiring three therapists and equipment costing over $20 000. It is usually performed in a clinic or hospital setting, requiring the family to wait while the intervention is performed 1–2 hours per day, two to five times per week. Willoughby[17] has suggested that for children with cerebral palsy, overground training might be as effective as treadmill training. In rural West Virginia, our participant was able to commute to the clinic a few times a week, as well as continue her gait intervention in the home and community, enhancing her activity and participation. She used her dynamic gait trainer without direct adult assistance beginning at age 3 during a weekly dance class and was also able to use this device to participate in community dance recitals alongside her peers. During dance class, she emerged as a leader, the dancer that the others looked to see which move came next.

Her lack of improvement on GMFM scores support the premise that her improvement in independent ambulation was not the result of sensorimotor recovery, but rather a result of provision and training on appropriate equipment. By offering dynamic body weight support and having her centre of mass aligned with the centre of mass of the gait trainer, she was able to move with minimal muscle power.[18]

The success of this single participant suggests that more research is needed to explore the benefits of overground training on activity and participation in children with SCI. We believe a combination of treadmill and overground training approaches might improve the ICF core sets for SCI.

Learning points

- A child with traumatic spinal cord injury T10 (thoracic level, vertebra 10) Association Impairment Scale A continued to make gains in activity and participation, with neither neurological improvement nor AIS change. Neither this level of change nor use of a gait trainer has been documented previously in this population.
- She used power as the primary mode for mobility, but enjoyed using a dynamic gait trainer for dance and other community activities.
- This case offers a reasonable expectation that some children may be able to use a dynamic gait trainer in their home and community to improve activity and participation, even in the absence of neural recovery.

In paediatric rehabilitation, we need to focus on activity and participation while monitoring body structure and function. Overground training that can be incorporated into naturally occurring family routines as well as community activities (dance class and recital) might be preferable to clinic-based interventions alone. While randomised controlled studies might not be possible because of the low incidence of SCI, case–control studies might help to show effective methods and dosages of therapy.

Contributors WA conceived treatment strategies, administered all testing, provided intervention and assistive devices, edited and approved the final version of the manuscript. GN edited and revised the manuscript for content and approved the final version. GP wrote, edited and revised the manuscript for content and approved the final version.

Competing interests None declared.

Patient consent Obtained.

Provenance and peer review Not commissioned; externally peer reviewed.

REFERENCES

1 Vitale MG, Goss JM, Matsumoto H, *et al*. Epidemiology of pediatric spinal cord injury in the United States: years 1997 and 2000. *J Pediatr Orthop* 2006;26:745–9.
2 Greenberg JS, Ruutiainen AT, Kim H. Rehabilitation of pediatric spinal cord injury: From acute medical care to rehabilitation and beyond. *J Pediatr Rehabil Med* 2009;2:13–27.
3 McDonald JW, Sadowsky C. Spinal-cord injury. *Lancet* 2002;359:417–25.
4 McCarthy JJ, Chafetz RS, Betz RR, *et al*. Incidence and degree of hip subluxation/dislocation in children with spinal cord injury. *J Spinal Cord Med* 2004;27:S80–S83.
5 Mehta S, Betz RR, Mulcahey MJ, *et al*. Effect of bracing on paralytic scoliosis secondary to spinal cord injury. *J Spinal Cord Med* 2004;27:S88–S92.
6 Mulcahey MJ, Gaughan JP, Betz RR, *et al*. Neuromuscular scoliosis in children with spinal cord injury. *Top Spinal Cord Inj Rehabil* 2013;19:96–103.
7 Diong J, Harvey LA, Kwah LK, *et al*. Incidence and predictors of contracture after spinal cord injury-a prospective cohort study. *Spinal Cord* 2012;50:579–84.
8 Behrman AL, Nair PM, Bowden MG, *et al*. Locomotor training restores walking in a nonambulatory child with chronic, severe, incomplete cervical spinal cord injury. *Phys Ther* 2008;88:580–90.
9 Paleg G, Livingstone R. Outcomes of gait trainer use in home and school settings for children with motor impairments: a systematic review. *Clin Rehabil* 2015;29:1077–91.
10 Paleg GS, Smith BA, Glickman LB. Systematic review and evidence-based clinical recommendations for dosing of pediatric supported standing programs. *Pediatr Phys Ther* 2013;25:232–47.
11 Livingstone R, Paleg G. Measuring outcomes for children with cerebral palsy who use gait trainers. *Technologies* 2016;4:22.
12 Iyer LV, Haley SM, Watkins MP, *et al*. Establishing minimal clinically important differences for scores on the pediatric evaluation of disability inventory for inpatient rehabilitation. *Phys Ther* 2003;83:888–98.
13 Itzkovich M, Gelernter I, Biering-Sorensen F, *et al*. The Spinal Cord Independence Measure (SCIM) version III: reliability and validity in a multi-center international study. *Disabil Rehabil* 2007;29:1926–33.
14 Malouin FRC, Menier C, Dumas F, *et al*. Supported Walker Ambulation Performance Scale (SWAPS): development of an outcome measure of locomotor status in children with cerebral palsy. *Pediatr Phys Ther* 1997;9:48–53.
15 Rivi E, Filippi M, Fornasari E, *et al*. Effectiveness of standing frame on constipation in children with cerebral palsy: a single-subject study. *Occup Ther Int* 2014;21:115–23.
16 Fox EJ, Tester NJ, Phadke CP, *et al*. Ongoing walking recovery 2 years after locomotor training in a child with severe incomplete spinal cord injury. *Phys Ther* 2010;90:793–802.
17 Willoughby KL, Dodd KJ, Shields N, *et al*. Efficacy of partial body weight-supported treadmill training compared with overground walking practice for children with cerebral palsy: a randomized controlled trial. *Arch Phys Med Rehabil* 2010;91:333–9.
18 Paleg G, Huang M, Vasquez Gabela SC, *et al*. Comparison of the inertial properties and forces required to initiate movement for three gait trainers. *Assist Technol* 2016;28:137–43.