Duke University School of Medicine

Doctor of Physical Therapy

Interventions for Gait Training in Children with Spinal Cord Impairments: A Scoping Review

Sarah Funderburg, SPT, Hannah Josephson, SPT, Ashlee Price, SPT, Maredith Russo, SPT
Laura Case, PT, DPT, MS, PCS, C/NDT. Duke University, Durham, NC.

Background

Spinal cord impairments, including spina bifida and spinal cord injury (SCI), have significant effects on a child's ability to ambulate. Approximately 1,500 children each year are born with the neural tube defect, spina bifida (CDC, 2015), and 10% of traumatic SCIs occur in individuals under the age of 15 (Parent et al, 2010). The most common causes of pediatric SCI include motor vehicle accidents in children and sports injuries in adolescents. Research of interventions to improve gait in this population is limited, and most systematic reviews of gait facilitation in pediatrics have addressed other disorders (Domiano et al, 2009).

Purpose

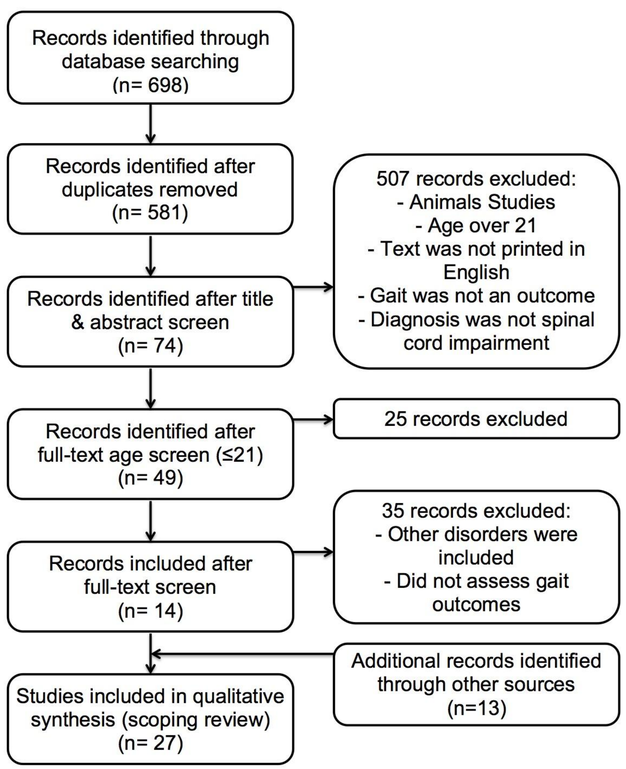
The purpose of this study was to review the current literature and determine trends for interventions to improve gait in children with spinal cord impairments.

Methods

A scoping review was conducted to identify relevant citations from PubMed, Embase, and CINAHL.

- Inclusion criteria: English written papers only, human research, pediatric population (age ≤ 21), diagnosis of spinal cord impairment (spinal cord injury or spina bifida), intervention performed, gait as an outcome
- Exclusion criteria: systematic reviews, scoping reviews

Figure 1: Search Strategy Flow Chart



Results

Table 1: A Summary of Interventions for Children with Spinal Cord Impairments

Intervention	Subjects	Results	Level of Evidence
Orthotics HKAFO[7, 16, 24] RGO[7, 11, 12, 16, 24] HGO[22] Swivel walker[17] Parapodium[17]	76 children (3.5-15 y/o) with myelomeningocele 21 children (3-21 y/o) with myelodysplasia 15 children (2-9) with myelomeningocele and paraplegia 18 children (2-11) with myelomeningocele or spinal cord injury	• Improvement in ambulatory status with HGO • Increased speed with HGOs, RGOs, and HKAFOs • Increased energy efficiency and use of swing through gait pattern with RGOs and HKAFOs • Improvement to household or community ambulation with RGOs • Conflicting evidence on whether RGOs or HKAFOs were more effective for improving gait speed and efficiency of gait/energy cost • RGOs preferred over HKAFOs by more subjects • Swivel walker was significantly slower than parapodium but required less energy and had better gait efficiency.	Level 3: 4/7 Level 4: 3/7
Orthotics AFO[9, 25] Forearm crutches[26]	50 children (4-19 y/o) with myelomeningocele	• Increase in walking speed, step length, hip flexion at initial contact, and ankle power generation at terminal stance when wearing AFOs vs. barefoot walking. There were variable results for increases in cadence. An AFO may be detrimental for those with S1/2 level lesions. • With crutches, stride length was greater and pelvic rotation dynamic ROM was closer to normal. Cadence was greater with non-crutch walking.	Level 3: 3/3
Soft Tissue Release[6]	32 children (1.8-13 y/o) with myelomeningocele	• Ten of thirty-two children improved in ambulation. Six children were able to walk in KAFOs rather than HKAFOs. Two children were able to walk in AFOs rather than HKAFOs, and two progressed from household to community ambulators.	Level 4: 1/1
Electrical Stimulation FES (Percutaneous)[4, 5, 14]	9 children (9-18 y/o) children with spinal cord injury	• Increased mean gait velocity and maximum ambulation • Significantly higher oxygen consumption with FES • No significant differences for energy expenditure during ambulation and time to complete 6m walk.	Level 3: 1/3 Level 4: 1/3 Level 5: 1/3
Electrical Stimulation FES (Implantable)[3, 13]	10 children (7-20 y/o) with thoracic spinal cord injury	• Conflicting results on whether time to complete 6m walk can be improved with FES • No significant changes in FIM score for 6m walk.	Level 3: 1/2 Level 5: 1/2
Electrical Stimulation NMES[15]	5 children (5-21 y/o) with spina bifida	• Decreased time to complete 24.4m free walking task	Level 3: 1/1
Electrical Stimulation Nighttime Threshold Stimulation[27]	15 children (4-12 y/o) with myelomeningocele	• Four of seven children improved in walking velocity and gait mechanics. • One child improved a level on the progressive ambulation scale.	Level 4: 1/1
Treadmill Training[1, 2, 8, 10, 19, 21]	7 children (4.5-17 y/o) with spinal cord injury 41 children (6-18 y/o) with spina bifida	• Increased gait speed, walking independence scores, distance (6MWT), FGA scores, and use of less restrictive assistive devices	Level 2: 1/6 Level 4: 2/6 Level 5: 3/6
Infant Treadmill Training[18, 20, 23]	39 infants with myelomeningocele 6 infants with spina bifida	• Increased step frequency, leg activity, and step rate	Level 3: 3/3

Table 1. Abbreviations: HKAFO, hip-knee-ankle-foot orthosis; RGO, reciprocating gait orthosis; HGO, hip guidance orthosis; AFO, ankle-foot orthosis; FES, functional electrical stimulation; NMES; neuromuscular electrical stimulation; FGA, functional gait assessment

References: [1]**Behrman** AL et al. *Phys Ther.* 2008, [2]**Behrman** AL et al. *Journal of Pediatric Rehabilitation Medicine.* 2012, [3]**Betz** RR et al. *Journal of Spinal Cord Medicine.* 2002, [4]**Bonaroti** D et al. *Journal of Spinal Cord Medicine.* 1999, [5]**Bonaroti** D et al. *Archives of Physical Medicine and Rehabilitation.*1999, [6]**Correll** J et al. *J Pediatr Orthop B.* 2000, [7]**Cuddeford** TJ et al. *Dev Med Child Neurol.* 1997, [8]**de Groot** JF et al. *Neurorehabil Neural Repair.* 2011, [9]**Duffy** CM et al. *J Pediatr Orthop.* 2000, [10]**Fox** EJ et al. *Phys Ther.* 2010, [11]**Gerritsma-Bleeker** CLE et al. *Acta Orthopaedica Scandinavica.* 1997, [12]**Guidera** KJ et al. *J Pediatr Orthop.* 1993,[13]**Johnston** TE et al. *Spinal Cord.* 2003, [14]**Johnston** TE et al. *Journal of Spinal Cord Medicine.* 2003, [15]**Karmel-Ross** K et al. *Phys Ther.* Oct 1992, [16]**Katz** DE et al. *J Pediatr Orthop.* 1997, [17]**Lough** LK et al. *Devel Med Child Neurol.* 1986, [18]**Moerchen** VA et al. *Pediatr Phys Ther.* 2013, [19]**O'Donnell** CM et al. Spinal Cord. 2013. [20]**Pantall** A et al. *Pediatr Phys Ther.* 2011. [21]**Prosser** LA. *Phys Ther.* 2007, [22]**Rose** GK et al. *Devel Med Child Neurol.* 1981, [23]**Teulier** C et al. *Phys Ther.* 2009, [24]**Thomas** SS et al. *J Pediatr Orthop.* 2001, [25]**Thomson** JD et al *J Pediatr Orthop.* 1999, [26]**Vankoski** S et al. *Dev Med Child Neurol.* 1997, [27]**Walker** JL et al. *Clin Orthop Relat Res.* 2011.

- Majority of articles included (78%) classified as Levels of Evidence III & IV.
- Most failed to report allocation assignments, blinding, and random sequence generation, implying a risk of bias, supporting the need for additional research.

Conclusions

This scoping review examined interventions for gait in individuals with pediatric spinal cord impairments, which, to our knowledge, had not been previously reported. Interventions studied included orthotic intervention, electric stimulation, soft tissue release, and treadmill training, with benefits reported on various components of gait for each intervention. The review revealed that interventions tended to target specific outcomes, highlighting the importance of identifying individual patient characteristics and goals appropriate for each intervention to help guide clinical practice. The studies included were primarily low level evidence, and only one article was a randomized controlled trial, which suggests the need for further research.

Figure 2. Treadmill Training with an Infant with Spina Bifida. Modified from Nazario, Beth. (2008, April 18). Spina Bifida Study. www.flickr.com/photos/bnazario/2486931037 www.flickr.com/photos/bnazario/2486930693.

Figure 3. Treadmill Training with a Child with Incomplete Spinal Cord Injury. Reprinted from Behrman et al "Locomotor Training Restores Walking in a Nonambulatory Child With Chronic, Severe, Incomplete Cervical Spinal Cord Injury." Phys Ther. 2008; 88 (5) 580-590, with permission of the American Physical Therapy Association. © 2008 American Physical Therapy Association.

Clinical Relevance

Determining the appropriate orthotic support for each child, as well as incorporating treadmill training and/or electrical stimulation is recommended. Infant stepping on a treadmill in the spina bifida population showed promising effects in increasing movement; however, future research to determine long term effects on gait and mobility is still needed. Individualized assessment is important in determining the optimal combination of interventions based on individual characteristics and response to intervention. All treatment decisions should consider each child's lesion level, current and previous level of function and ambulation goals, as well as considering physical, social, and environmental factors.

Acknowledgements / References

CDC. 2015. Spina Bifida Homepage. *Centers for Disease Control and Prevention.*

Domiano DL and DeJong SL. A systematic review of the effectiveness of treadmill training and body weight support in pediatric rehabilitation. *J Neurol Phys Ther.* 2009 Mar;33(1):27-44.

Parent S, Mac-Thiong JM, Roy-Beaudry M, Sosa JF, Labelle H. Spinal cord injury in the pediatric population: a systematic review of the literature. *J Neurotrauma.* 2011 Aug;28(8):1515-24.

Parent S, Dimar J, Dekutoski M, Roy-Beaudry M. Unique features of pediatric spinal cord injury. *Spine* (Phila Pa 1976). 2010 Oct 1;35(21 Suppl):S202-8.

We would like to thank Leila Ledbetter MLIS, for assisting with our literature searches and Chad Cook, PT, PhD, MBA, FAAOMPT, for assisting with the editing process.