Clinical Decision Making Regarding Lower Extremity Orthotic Intervention for Children with Spastic Cerebral Palsy: Systematic Review

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Background

- Spastic cerebral palsy is a neurologically based disorder of movement or posture that commonly leads to gait impairments, treated with lower extremity (LE) orthoses[1]
- 764,000 people in the US have CP, over 50% are prescribed orthoses[2]
- Literature lacks a set of comprehensive evidence supported guidelines for orthotic intervention

Purpose

- Expand upon a systematic review performed by Neto et al in 2010[3]
- Create guidelines for clinical decision making regarding LE orthotic intervention for children with spastic CP

Methods

- Searches carried out in 3 databases: PubMed, Embase, CINAHL
- Inclusion criteria: children with diplegic and hemiplegic spastic cerebral palsy (15 months to 18 years), LE orthotic interventions used for gait, clinical decision making, gait analysis, energy conservation
- PRISMA: 184 studies evaluated, 13 studies included

Gait Cycle

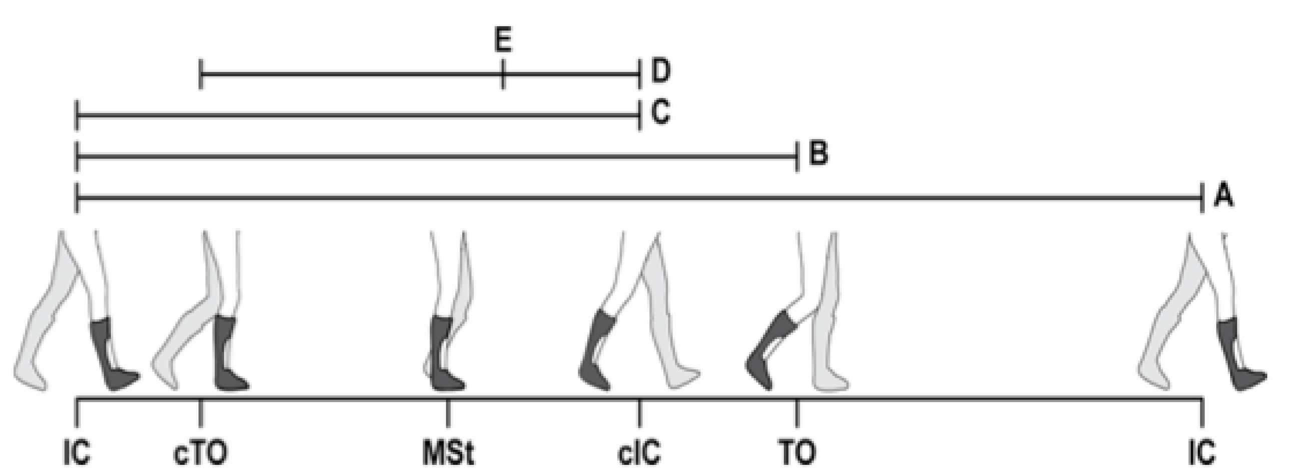

Figure 1: Representation of relevant phases of the gait cycle. Phases of the gait cycle were defined as i) stance: initial contact to toe-off; ii) step: initial contact to contralateral initial contact; iii) single support (SS): contralateral toe-off to contralateral initial contact. Definitions of specific gait events and mean timing [%gait cycle]: i) contralateral toe-off (cTO) [11%]; ii) midstance (MSt): the moment that the malleolus marker of the contralateral leg passed the malleolus marker of the ipsilateral leg [33%]; iii) contralateral initial contact (cIC) [50%]; iv) toe-off (TO) [64%]; v) timing of minimal knee flexion angle during single support (peak knee extension angle) (TKEpk): [38%]. *Abbreviations*: *cTO*, *contralateral toe-off; cIC*, *contralateral initial contact; IC*, *initial contact; TKEpk*, *timing of peak knee extension angle; MSt*, *midstance; SS*, *single support; TO*, *toe-off*.

From Kerkum, Y. L., et al. (2015): The Effects of Varying Ankle Foot Orthosis Stiffness on Gait in Children with Spastic Cerebral Palsy Who Walk with Excessive Knee Flexion: Fig. 3. PLoS One 10(11): e0142878. Used with permission

Results and Clinical Decision Making Considerations

Article	Intervention	Outcome Measures	Outcome change: only significant data reported			
Abd El-Kafy et al.	Group B – PT & TheraTogs Group C – PT, TheraTogs, & GR SAFOs	**Hip Flexion angle**	*Right* A&C: 8.98° A&B: 5.26° B&C: 3.71° *Left* A&C: 3.74° B&C: 1.89°			
		Knee flexion angle	*Right* A&C: 7.12° B&C: 6.48° *Left* A&C: 3.9° B&C: 4.55°			
Bennett et al.	Prescribed articulated or solid bilateral AFOs		**No AFO**		**Prescribed AFO**	
		Recovery factor	40%		48.10%	
		CoM vertical excursion (cm)	3.4		4.1	
		KE variation (J/kg)	0.16		0.22	
Dalvand et al.	HAFO group w/ 3 months of OT SAFO group: SAFO w/ 3 months of OT		**HAFO**		**SAFO**	
		Average GMFM score before	26.12		29.88	
		Average GMFM score after	33.97		35.43	
Danino et al.	Prescribed orthoses	**Mean change in Foot progression angle**	**Mid-stance** *R:* 4.29 *L:* 5.42		**Mid-swing** *R:* 3.72 *L:* 3.94	
		Correlation between rotational profile and foot progression angle (Pearson correlation)	*Braces:* Femoral AV: 0.353 TFA: 0.413	*Barefoot:* Femoral AV: 0.333 TFA: 0.281	*Braces:* Femoral AV: 0.256 TFA: 0.548	*Barefoot:* Femoral AV: 0.3 TFA: 0.343
Kerkum et al. (2015)	Ventral shell AFO (vAFO) at stiffness levels rigid, stiff, or flexible		**Shoes**	**Stiff**	**Rigid**	**Flexible**
		Knee flexion angle at mid stance	34.8°	31.8°	30.5°	29.7°
		Peak angle power generation at push-off (Wkg^-1)	1.49	0.73	1.21	1.19
Kerkum et al. (2016)	Ventral shell AFO (vAFO) at stiffness levels rigid, stiff, or flexible		**Difference in percentage between optimized AFO and shoes-only**			
		Shank to vertical angle	5.2°			
		Kinetic energy	2.4°			
Maltais et al.	Transcutaneous peroneal (fibular) FES	**Reduction in VO_{2net} w/ AFO on**	*3* km-h^{-1}: .9% *90% fastest walking speed:* 5.9%			
		Reduction in VE_{net} with AFO on	*3* km-h^{-1}: 10.3%			
Meilahn et al.	Transcutaneous peroneal (fibular) FES	**Gait velocity** (cm/s)	Increased in 50% of participants, Others remained consistent			
		Ankle kinematics	Normalization in 3 patients			
		Preference over normal AFO	*3 weeks:* 89% *6 weeks:* 78% *3 months:* 71%			
Pauk et al.	Group 1 - Spastic diplegia w/ prescribed AFOs for 1 year Group 2 - Spastic diplegia w/out AD	*Plantar pressure [N/cm^2]*				
		Toes	-2.6			
		Metatarsal heads	-4			
		Medal arch	-1.3			
		Heel	2.5			
Pool et al.	8 weeks of daily FES. Four hours per day, 6 days per week	**Lower limb gait mechanics**	**Mean difference compared to control group**			
			Initial contact ankle angle	11.9°		
			Max DF angle in swing	8.1°		
			Normalized time in stance	0.27		
		Gastrocnemius spasticity (ASAS scale)	Significantly reduced post treatment and at follow-up			
		Dynamic DF range of motion difference	*Follow-up:* 6.9°			
Ries et al.	SAFO, PLS, or Hinged AFO		**Mean change in AFOs**			
		Speed (ND)	0.042 surpassed MCID value			
		Step length (ND)	0.115 surpassed MCID value			
Schweizer et al.	Hinged AFO		**Hinged AFO**		**Barefoot**	
		Pelvic tilt ROM	6.6°		7.5°	
		Shoulder abduction ROM	12.1°		14.3°	
Van Gestel et al.	Group 1 – Orteam Group 2 – PLS Group 3 – CFO		**Orteam**	**PLS**	**CFO**	
		Ankle dorsiflexion at initial contact	10.4°	11.2°	5.3°	
		Maximal hip flexion moment in stance (Nm/kg)	-0.06	-0.2	-0.29	

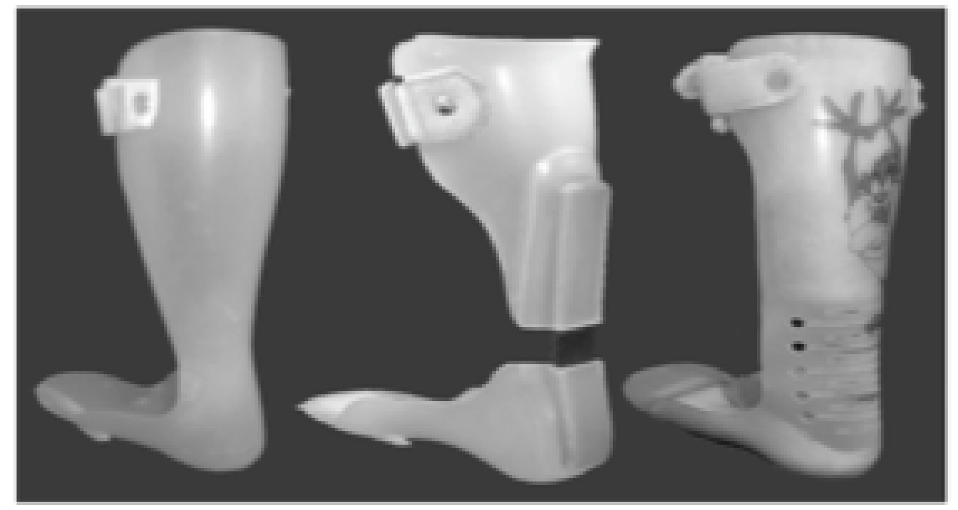

Figure 2: L to R: Posterior leafspring (PLS), Dual Carbon Fibre Spring AFO (CFO)®, and Orteams®. From Van Gestel, L., et al. (2008): Effect of dynamic orthoses on gait: a retrospective control study in children with hemiplegia: Fig 1, Dev Med Child Neurol **50**(1): 63-67. Used with permission.

Figure 3: The Pediatric WalkAide® System. Image used with permission http://www.walkaide.com

Key Findings

- Optimal stiffness level is a balance between improving knee and ankle kinematics & enhancing push-off power and maintaining range of motion
- Orthoses can impact foot progression angle (FPA)
- FES systems demonstrated post treatment improvements in dynamic dorsiflexion and gastrocnemius spasticity
- Significant impact on the trunk, upper extremities, or plantar pressure was not demonstrated with LE orthoses

Conclusions

- Orthotic intervention improves gait kinematics compared to barefoot or shoes only
- The best orthosis is the type optimized for the individualized impairments and needs of the patient

Clinical Relevance

- Orthoses are a widely used therapeutic intervention used to facilitate and improve the gait pattern
- Cerebral palsy presents with multifaceted symptoms rather than a set of specific impairments and the type of orthotic intervention needs to be optimized for each child's gait limitations.

Acknowledgements / References

1. Meilahn, J. R. (2013). "Tolerability and effectiveness of a neuroprosthesis for the treatment of footdrop in pediatric patients with hemiparetic cerebral palsy." Pm r **5**(6): 503-509

1. Bennett, B. C., et al. (2012). "The effects of ankle foot orthoses on energy recovery and work during gait in children with cerebral palsy." Clin Biomech (Bristol, Avon) **27**(3): 287-291.

2. Neto, H. P., et al. (2012). "Comparison of articulated and rigid ankle-foot orthoses in children with cerebral palsy: a systematic review." Pediatr Phys Ther **24**(4): 308-312.