



## Best Evidence Statement (BESt)

**Date published/posted: 1/15/2010**

### Lower Extremity Orthoses for Children with Hemiplegic Cerebral Palsy<sup>1</sup>

#### Clinical Question

- P** (population/problem): Among children ages 0-12 years diagnosed with hemiplegic cerebral palsy
- I** (intervention): do orthoses
- C** (comparison) as compared to no orthoses
- O** (outcome): improve function and/or decrease impairment?

**Target Population:** Children diagnosed with hemiplegic cerebral palsy, age 0-12 years

#### Inclusions:

- Children up to 12 years of age who present with a diagnosis of hemiplegic cerebral palsy and hemiparesis according to the DSM IV criteria.
- Children with impairments in: strength, range of motion, balance, posture, body coordination, motor control, joint mobility, pain, muscle tone, functional independence and/or gross motor skill development, secondary to a diagnosis of hemiplegic cerebral palsy.

#### Exclusions:

- Children with a diagnosis of hemiplegia that do not also have a diagnosis of cerebral palsy
- Children with significant cognitive delay who are unable to follow multi-step directions or to comply with recommendations.
- Children not ambulatory by age 3.

#### Recommendation(s)

1. It is recommended that orthoses be considered for children diagnosed with hemiplegic cerebral palsy who demonstrate an abnormal gait pattern or musculoskeletal misalignment of the lower extremities.

**Note 1:** There is evidence to support the use of orthoses to improve the following:

- gait parameters: (temporal-spatial) velocity, step-length, cadence, stride length, single leg stance, and decreased double limb support time, energy expenditure (*Radtka 1997 [2b], Van Gestel 2008 [4a], Balaban 2007 [4a], Romkes 2006 [4a], Romkes 2002 [4a], Thomas 2002 [4a], Thompson 2002 [4a], White 2002 [4a], Buckon 2001 [4a], Hainsworth 1997 [4a], Yokoyama 2005 [5], Morris 2002 [5]*).
- joint kinematics: dorsiflexion, plantar flexion, hip position, knee position, foot alignment (*Radtka 1997 [2b], Van Gestel 2008 [4a], Balaban 2007 [4a], Westberry 2007 [4a], Romkes 2006 [4a], Romkes 2002 [4a], Thomas 2002 [4a], Thompson 2002 [4a], Buckon 2001 [4a], Hainsworth 1997 [4a], Yokoyama 2005 [5], Morris 2002 [5]*).
- gross motor skills: as measured via the Gross Motor Function Measure, the Gross Motor Performance Measure or the Pediatric Evaluation of Disability Inventory (*Thomas 2002 [4a], Buckon 2001 [4a], Morris 2002 [5]*).

**Note 2:** In addition, one study by Hainsworth suggests that lower extremity orthotics prevent the deterioration of gait and range of motion (*Hainsworth 1997 [4a]*).

<sup>1</sup> Please cite as: Conner, S., Maignan, S. Burch, C. Christensen, C. Colvin, C., Hall, K. Cincinnati Children's Hospital Medical Center: Best Evidence Statement for Lower Extremity Orthoses for Children with Hemiplegic Cerebral Palsy; <http://www.cincinnatichildrens.org/svc/alpha/h/health-policy/best.htm>, BESt 027, pages 1-15, 11-20-09.

2. It is recommended that the selection of orthosis (i.e. hinged ankle foot orthoses versus a supramalleolar orthoses) reflect the assessed needs and goals for improvement of the child (*Van Gestel 2008 [4a], Romkes 2006 [4a], Romkes 2002 [4a], Thomas 2002 [4a], Thompson 2002 [4a], Buckon 2001 [4a], Yokoyama 2005 [5], Morris 2002 [5], Local Consensus [5]*). See Appendix 1.
3. It is recommended that clinicians check the orthoses for proper fit and function initially and periodically and educate caregivers for signs that the child has outgrown the orthoses and/or may no longer be benefiting from it (*Local Consensus [5]*).
4. It is recommended that clinicians collaborate with the patient and family when recommending an orthosis. Any financial and/or social concerns should be discussed with the family (*Local Consensus [5]*).
5. It is recommended that when an orthosis is fabricated by a third party, the clinicians discuss the design elements of the orthoses with the third party to assist in maximizing the success of the orthoses (*Local Consensus [5]*). Design elements may include density of plastic, contouring capabilities to capture foot intrinsic alignment and pressure relief and padding.

### Discussion/summary of evidence

There is consensus in the evidence that supports the use of orthoses to normalize gait in children diagnosed with hemiplegic cerebral palsy. There is conclusive evidence that supports the use of orthoses to specifically correct an equino-varus gait pattern (*Autti-Ramo 2006 [1a], Van Gestel 2008 [4a], Balaban 2007 [4a], Westberry 2007 [4a], Romkes 2006 [4a], Romkes 2002 [4a], Thomas 2002 [4a], Thompson 2002 [4a], White 2002 [4a], Buckon 2001 [4a], Hainsworth 1997 [4a], Yokoyama 2005 [5], Morris 2002 [5]*). Many temporal-spatial parameters of gait are shown to be statistically and clinically improved by use of an orthosis such as: velocity, step-length, cadence, stride length, single leg stance, decreased double limb support time, and energy expenditure (*Van Gestel 2008 [4a], Balaban 2007 [4a], Westberry 2007 [4a], Romkes 2006 [4a], Romkes 2002 [4a], Thomas 2002 [4a], Thompson 2002 [4a], White 2002 [4a], Buckon 2001 [4a], Hainsworth 1997 [4a], Yokoyama 2005 [5]*). Joint kinematics, such as, dorsiflexion, plantar flexion, hip position, and knee position were also shown to improve (*Van Gestel 2008 [4a], Balaban 2007 [4a], Westberry 2007 [4a], Romkes 2006 [4a], Romkes 2002 [4a], Thomas 2002 [4a], Thompson 2002 [4a], Buckon 2001 [4a], Hainsworth 1997 [4a], Yokoyama 2005 [5], Morris 2002 [5]*). There is also evidence supporting the use of orthoses to improve gross motor skills in both function and quality (including stair negotiation skills) (*Thomas 2002 [4a], Buckon 2001 [4a]*). One study indicated that range of motion and gait deteriorated during trial periods where orthoses were not worn (*Hainsworth 1997 [4a]*).

Evidence suggests that the **type of orthosis** selected depends upon the severity of motor impairment and individual factors (*Radtka 1997 [2b], Morris 2002 [5]*). Patients with no volitional control of dorsiflexion and an equinus gait pattern, will benefit from an orthosis that strongly prevents this deviation, such as a solid ankle foot orthoses or thick plantar flexion-resist style orthoses (“posterior spring” type) (*Morris 2002 [5]*). Patients with some volitional control and less severe equinus would more likely benefit from a less restrictive orthosis (*Romkes 2002 [4a], Morris 2002 [5]*). If a child has active dorsiflexion with knee extension a least-restrictive, supramalleolar style is best (*Local Consensus [5]*).

Typical gait involves plantar flexion at terminal stance. This allows the body to advance beyond the stance limb, creating potential kinetic energy that then acts to swing the leg through with a passive pendulum arc instead of requiring a “push-off” or marching pattern. Consider an orthosis that allows this plantar flexion at terminal stance either through use of a hinged orthosis with free plantar flexion or a carbon fiber type orthosis that stores kinetic energy (*Van Gestel 2008 [4a], Yokoyama 2005 [5]*). If choosing a hinged orthosis to accomplish this, the joint should allow free plantar flexion and have a dorsiflexion assist spring to achieve toe clearance during swing. If choosing a carbon-fiber type (similar to a posterior leaf spring), then the leaf spring acts to store kinetic energy during plantar flexion and will assist dorsiflexion for toe clearance during swing.

Correction of musculoskeletal alignment in the foot and ankle is often a goal of orthotic intervention. Joint alignment and range of motion are shown to be impacted by positioning in an orthosis. One study examined the bony alignment changes in the foot that are immediately impacted by orthotic use using radiographic imaging. Statistical significance was found in such measures as calcaneal and talus position. 25-40% of children achieved a “normal” characteristic of some alignment measure when wearing an orthosis (*Westberry 2007 [4a]*). This supports the use of orthoses to assist in correction of bony alignment, as part of a holistic and functional approach to posture and motor skills.

### **Health Benefits, Side Effects and Risks**

The health benefits of orthotic use include improvements in gait, alignment, dynamic range of motion and some areas of gross motor skills; particularly those that involve advanced ambulation and balance skills (*Autti-Ramo 2006 [1a], Van Gestel 2008 [4a], Balaban 2007 [4a], Westberry 2007 [4a], Romkes 2006 [4a], Romkes 2002 [4a], Thomas 2002 [4a], Thompson 2002 [4a], White 2002 [4a], Buckon 2001 [4a], Hainsworth 1997 [4a], Yokoyama 2005 [5], Morris 2002 [5]*). Side effects and risks are skin tolerance, cost and compliance which could negatively impact success (*Local Consensus [5]*).

## References/citations

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**Note:** Full tables of evidence grading system available in separate document:

- Table of Evidence Levels of Individual Studies by Domain, Study Design, & Quality (abbreviated table below)  
<http://groups.ce/NewEBC/EBCFiles/Table-EvidenceLevels.pdf>
- Grading a Body of Evidence to Answer a Clinical Question  
<http://groups.ce/NewEBC/EBCFiles/GradingBodyOfEvidence.pdf>
- Judging the Strength of a Recommendation (abbreviated table below)  
<http://groups.ce/NewEBC/Judgingthestrengthofarecommendation.pdf>

**Table of Evidence Levels** (see note above)

<i>Quality level</i>	<i>Definition</i>
1a† or 1b†	Systematic review, meta-analysis, or meta-synthesis of multiple studies
2a or 2b	Best study design for domain
3a or 3b	Fair study design for domain
4a or 4b	Weak study design for domain
5	Other: General review, expert opinion, case report, consensus report, or guideline

†a = good quality study; b = lesser quality study

**Table of Recommendation Strength** (see note above)

<i>Strength</i>	<i>Definition</i>
“Strongly recommended”	There is consensus that benefits clearly outweigh risks and burdens (or visa-versa for negative recommendations).
“Recommended”	There is consensus that benefits are closely balanced with risks and burdens.
No recommendation made	There is lack of consensus to direct development of a recommendation.
<p><i>Dimensions:</i> In determining the strength of a recommendation, the development group makes a considered judgment in a consensus process that incorporates critically appraised evidence, clinical experience, and other dimensions as listed below.</p> <ol style="list-style-type: none"> <li>1. Grade of the Body of Evidence (see note above)</li> <li>2. Safety / Harm</li> <li>3. Health benefit to patient (<i>direct benefit</i>)</li> <li>4. Burden to patient of adherence to recommendation (<i>cost, hassle, discomfort, pain, motivation, ability to adhere, time</i>)</li> <li>5. Cost-effectiveness to healthcare system (<i>balance of cost / savings of resources, staff time, and supplies based on published studies or onsite analysis</i>)</li> <li>6. Directness (<i>the extent to which the body of evidence directly answers the clinical question [population/problem, intervention, comparison, outcome]</i>)</li> <li>7. Impact on morbidity/mortality or quality of life</li> </ol>	

## Supporting information

### Introductory/background information

Most children diagnosed with hemiplegic cerebral palsy will benefit from lower extremity orthotic management. An orthosis is an external device that is applied to a body part in order to promote optimal skeletal alignment and prevent secondary joint deformities, thereby improving function. “Orthoses are usually fabricated from high-temperature plastics, acrylics, leather, or metal, individually or in combination, and are intended for long term use. They are made by certified orthotists and some podiatrists. Lower extremity splints, although often modeled after orthoses, are made of low temperature thermoplastics and are limited in durability. Splints are made by trained therapists, orthopedic technicians, and some podiatrists and orthotists” (Cusick 1988 [5]).

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## **Search strategy**

### **1. Databases**

OVID MEDLINE  
OVID CINAHL

**Search Terms:** cerebral palsy, orthotic, orthos\$, hemiplegi\$, splints, children

**2. Limits and Filters:** English, humans

**3. Additional articles:** from reference lists

### **Known conflicts of interest:**

Conflict of interest declarations were completed by members of the BESt development team and none were found.

Copies of this Best Evidence Statement (BESt) are available online and may be distributed by any organization for the global purpose of improving child health outcomes. Website address: <http://www.cincinnatichildrens.org/svc/alpha/h/health-policy/ev-based/default.htm>

Examples of approved uses of the BESt include the following:

- copies may be provided to anyone involved in the organization's process for developing and implementing evidence based care;
- hyperlinks to the CCHMC website may be placed on the organization's website;
- the BESt may be adopted or adapted for use within the organization, provided that CCHMC receives appropriate attribution on all written or electronic documents; and
- copies may be provided to patients and the clinicians who manage their care.

Notification of CCHMC at [HPCEInfo@cchmc.org](mailto:HPCEInfo@cchmc.org) for any BESt adopted, adapted, implemented or hyperlinked by the organization is appreciated.

*Additionally, for more information about CCHMC Best Evidence Statements and the development process, contact the **Division of Occupational Therapy and Physical Therapy** at: 513-636-4651 or [OTPT@cchmc.org](mailto:OTPT@cchmc.org)*

**This Best Evidence Statement addresses only key points of care for the target population; it is not intended to be a comprehensive practice guideline. These recommendations result from review of literature and practices current at the time of their formulation. This Best Evidence Statement does not preclude using care modalities proven efficacious in studies published subsequent to the current revision of this document. This document is not intended to impose standards of care preventing selective variances from the recommendations to meet the specific and unique requirements of individual patients. Adherence to this Statement is voluntary. The**

**clinician in light of the individual circumstances presented by the patient must make the ultimate judgment regarding the priority of any specific procedure.**

**Reviewed by Cincinnati Children's Hospital Medical Center Evidence Federation**

## Appendix 1

## Evidence Based Decision Making for Orthotic Use in the Pediatric Hemiplegic Population

## Orthotic Devices

	Hinged Ankle Foot Orthosis (HAFO)	Hinged Ankle Foot Orthosis (HAFO) Oil Damper with free PF	Supramalleolar Orthosis (SMO)	Posterior Leaf spring Orthosis (PLS)	Solid Ankle Foot Orthosis (SAFO)
<b>Gait Kinematics</b>					
<b>Velocity</b>	<ul style="list-style-type: none"> <li>• *Increased self-selected pace <i>P</i>&lt;0.01 (<i>Balaban 2007 [4a]</i>); <i>P</i>&lt;0.05 (<i>Romkes 2006 [4a]</i>); <i>P</i>&lt;0.001(<i>White 2002 [4a]</i>)</li> <li>• Increased self-selected pace when ambulating 1-1.5km but not shorter distances of 7.5m <i>P</i>=0.0001 (<i>Buckon 2001 [4a]</i>)</li> <li>• No significant changes for 10m walk but increased velocity (<i>Romkes 2002 [4a]</i>)</li> <li>• No significant changes in velocity to ascend/ descend stairs (<i>Sienko Thomas 2002 [4a]</i>)</li> </ul>	<ul style="list-style-type: none"> <li>• *Increased when compared to a HAFO with PF stop <i>P</i>&lt;0.01 (<i>Yokoyama 2005 [5]</i>)</li> </ul>	<ul style="list-style-type: none"> <li>• No significant changes for 10m walk but increased velocity (<i>Romkes 2002 [4a]</i>)</li> </ul>	<ul style="list-style-type: none"> <li>• *Increased self-selected pace <i>P</i>=0.001 (<i>Van Gestel 2008 [4a]</i>)</li> <li>• No significant changes in velocity to ascend/descend stairs (<i>Sienko Thomas 2002 [4a]</i>)</li> <li>• * Increased self-selected pace when ambulating 1-1.5km but not shorter distances of 7.5m, <i>P</i>=0.0001 (<i>Buckon 2001 [4a]</i>)</li> </ul>	<ul style="list-style-type: none"> <li>• *Increased self-selected pace <i>P</i>&lt;0.001 (<i>White 2002 [4a]</i>)</li> <li>• * Increased self-selected pace when ambulating 1-1.5km but not shorter distances of 7.5m <i>P</i>=0.0001 (<i>Buckon 2001 [4a]</i>)</li> <li>• No significant changes in velocity to ascend/descend stairs (<i>Sienko Thomas 2002 [4a]</i>)</li> </ul>

	<b>Hinged Ankle Foot Orthosis (HAFO)</b>	<b>Hinged Ankle Foot Orthosis (HAFO) Oil Damper with free PF</b>	<b>Supramalleolar Orthosis (SMO)</b>	<b>Posterior Leaf spring Orthosis (PLS)</b>	<b>Solid Ankle Foot Orthosis (SAFO)</b>
<b>Cadence</b>	<ul style="list-style-type: none"> <li>• *Decreased <i>P</i>&lt;0.05 (Romkes 2006 [4a]); <i>P</i>&lt;0.002 (Buckon 2001 [4a])</li> <li>• *Decreased for children GMFM I and II group <i>P</i>&lt;0.001 (White 2002 [4a])</li> <li>• *Increased compared to barefoot; but velocity also increased though not reaching statistical significance <i>P</i>&lt;0.05 (Romkes 2002 [4a])</li> </ul>	<ul style="list-style-type: none"> <li>• *Increased when compared to a HAFO with PF stop <i>P</i>&lt;0.01 (Yokoyama 2005 [5])</li> </ul>	<ul style="list-style-type: none"> <li>• No significant changes for 10m walk but increased velocity (Romkes 2002 [4a])</li> </ul>	<ul style="list-style-type: none"> <li>• *Increased self-selected pace <i>P</i>=0.001 (Van Gestel 2008 [4a])</li> <li>• No significant changes in velocity to ascend/descend stairs (Sienko Thomas 2002 [4a])</li> <li>• * Increased self-selected pace when ambulating 1-1.5km but not shorter distances of 7.5m, <i>P</i>=0.0001 (Buckon 2001 [4a])</li> </ul>	<ul style="list-style-type: none"> <li>• *Increased self-selected pace <i>P</i>&lt;0.001 (White 2002 [4a])</li> <li>• * Increased self-selected pace when ambulating 1-1.5km but not shorter distances of 7.5m <i>P</i>=0.0001 (Buckon 2001 [4a])</li> <li>• No significant changes in velocity to ascend/descend stairs (Sienko Thomas 2002 [4a])</li> </ul>
<b>Stride Length</b>	<ul style="list-style-type: none"> <li>• *Increased <i>P</i>&lt;0.05 (Romkes 2006 [4a]); <i>P</i>&lt;0.05 (Romkes 2002 [4a]); <i>P</i>&lt;0.001 (White 2002 [4a]); <i>P</i>=0.0001 (Buckon 2001 [4a])</li> </ul>		<ul style="list-style-type: none"> <li>• *Increased <i>P</i>&lt;0.05 (Romkes 2002 [4a])</li> </ul>	<ul style="list-style-type: none"> <li>• *Increased, <i>P</i>=0.0001 (Buckon 2001 [4a])</li> <li>• *Increased <b>step length</b>, <i>P</i>=0.001 (Van Gestel 2008 [4a])</li> </ul>	<ul style="list-style-type: none"> <li>• *Increased (White 2002 [4a], Morris 2002 [5]); <i>P</i>=0.000 (Buckon 2001 [4a])</li> <li>• *Increased <b>step length</b>, <i>P</i>&lt;0.001 (Thompson 2002 [4a])</li> </ul>
<b>Energy Expenditure</b>	<ul style="list-style-type: none"> <li>• *Decreased energy cost at fast walk pace <i>P</i>=0.002 (Buckon 2001 [4a])</li> </ul>			<ul style="list-style-type: none"> <li>• No significant changes at fast walk or self-selected pace (Buckon 2001 [4a])</li> </ul>	<ul style="list-style-type: none"> <li>• No significant changes at fast walk or self-selected pace (Buckon 2001 [4a])</li> </ul>

	<b>Hinged Ankle Foot Orthosis (HAFO)</b>	<b>Hinged Ankle Foot Orthosis (HAFO) Oil Damper with free PF</b>	<b>Supramalleolar Orthosis (SMO)</b>	<b>Posterior Leaf spring Orthosis (PLS)</b>	<b>Solid Ankle Foot Orthosis (SAFO)</b>
<b>Energy Expenditure</b> <i>(continued)</i>	<ul style="list-style-type: none"> <li>• No significant change in EE at self-selected pace (<i>Buckon 2001 [4a]</i>)</li> <li>• *Decreased energy expenditure at "comfortable" pace of .5m/S on TM <math>P &lt; 0.05</math> (<i>Balaban 2007 [4a]</i>)</li> </ul>				
<b>Dorsiflexion</b>	<ul style="list-style-type: none"> <li>• *Increased/Normalized at IC to promote heel-toe gait <math>P &lt; 0.05</math> (<i>Romkes 2006 [4a]</i>); <math>P &lt; .05</math> (<i>Romkes 2002 [4a]</i>); <math>P = 0.0001</math> (<i>Buckon 2001 [4a]</i>); <math>P &lt; 0.01</math> (<i>Balaban 2007 [4a]</i>, <i>Morris 2002 [5]</i>))</li> <li>• *Increased ankle DF at IC and peak DF in stance <math>P = 0.0001</math> (<i>Buckon 2001 [4a]</i>); <math>P &lt; 0.01</math> (<i>Balaban 2007 [4a]</i>)</li> </ul>		<ul style="list-style-type: none"> <li>• *Improved DF at IC compared to barefoot, <math>P &lt; 0.05</math> (<i>Romkes 2002 [4a]</i>)</li> <li>• Produced heel-toe gait in 1/3 patients but not reaching statistical significance (<i>Romkes 2002 [4a]</i>)</li> </ul>	<ul style="list-style-type: none"> <li>• *Increased ankle DF at IC and peak DF in stance and normalized 1st ankle rocker <math>P = 0.007</math> (<i>Van Gestel 2008 [4a]</i>); <math>P = .0001</math> (<i>Buckon 2001 [4a]</i>)</li> <li>• Increased generally throughout gait (<i>Morris 2002 [5]</i>)</li> <li>• <b>Stairs:</b> *Increased in swing ↑ and ↓ stairs as compared to barefoot and SAFO, <math>P = 0.003</math> and <math>P = 0.0</math> (<i>Sienko Thomas 2002 [4a]</i>)</li> </ul>	<ul style="list-style-type: none"> <li>• *Increased ankle DF at IC and peak DF in stance <math>P = 0.0001</math> (<i>Buckon 2001 [4a]</i>); <math>P = 0.001</math> (<i>Thompson 2002 [4a]</i>)</li> <li>• *Increased DF at IC with HAFO and SAFO more so than PLS. <math>P = 0.002</math> and <math>P = 0.015</math>, (<i>Buckon 2001 [4a]</i>)</li> <li>• Increased generally throughout gait (<i>Morris 2002 [5]</i>)</li> </ul>
<b>Dorsiflexion</b> <i>(continued)</i>	<ul style="list-style-type: none"> <li>• * Increased DF at IC with HAFO and SAFO, better than PLS. <math>P = 0.002</math> and <math>P = 0.015</math> (<i>Buckon 2001 [4a]</i>)</li> <li>• *Peak DF in stance</li> </ul>			<ul style="list-style-type: none"> <li>• <b>Passive DF:</b> knee extension*improved compared to barefoot, <math>P = 0.007</math> (<i>Buckon 2001 [4a]</i>)</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Stairs:</b> *Increased in swing ↓ stairs, <math>P = 0.01</math> (<i>Sienko Thomas 2002 [4a]</i>)</li> <li>• <b>Passive DF:</b> knee extension unchanged</li> </ul>

	<b>Hinged Ankle Foot Orthosis (HAFO)</b>	<b>Hinged Ankle Foot Orthosis (HAFO) Oil Damper with free PF</b>	<b>Supramalleolar Orthosis (SMO)</b>	<b>Posterior Leaf spring Orthosis (PLS)</b>	<b>Solid Ankle Foot Orthosis (SAFO)</b>
	<p>with HAFO more so than PLS, and SAFO, <math>P=0.004</math> and <math>P=0.0001</math> (Buckon 2001 [4a])</p> <ul style="list-style-type: none"> <li>• *Increased at IC, mid-stance and midswing, <math>P&lt;0.01</math> (Balaban 2007 [4a])</li> <li>• *Decrease in activity of anterior tibialis (potential adverse), <math>P&lt;0.05</math> (Romkes 2006 [4a])</li> <li>• <b>Stairs:</b> *Increased in stance and swing ↑ and ↓ stairs as compared to barefoot and SAFO, <math>P&lt;0.001</math> (Thompson 2002 [4a])</li> <li>• <b>Passive DF:</b> knee extension*improved compared to barefoot, <math>P=0.007</math> (Buckon 2001 [4a])</li> </ul>				<p>compared to barefoot (Buckon 2001 [4a])</p>

	<b>Hinged Ankle Foot Orthosis (HAFO)</b>	<b>Hinged Ankle Foot Orthosis (HAFO) Oil Damper with free PF</b>	<b>Supramalleolar Orthosis (SMO)</b>	<b>Posterior Leaf spring Orthosis (PLS)</b>	<b>Solid Ankle Foot Orthosis (SAFO)</b>
<b>Plantarflexion</b>	<ul style="list-style-type: none"> <li>• *Reduced Equinus <math>P=0.0001</math>, (Sienko Thomas 2002 [4a]); <math>P&lt;0.05</math> (Romkes 2002 [4a]); <math>P&lt;0.05</math> (Romkes 2006 [4a]); <math>P&lt;0.01</math> (Balaban 2007 [4a], Buckon 2001 [4a])</li> <li>• *Decreased at TO (adverse change), <math>P&lt;0.05</math> (Romkes 2002 [4a]).</li> <li>• *Decreased peak PF during swing (desired change), <math>P&lt;0.05</math> (Romkes 2002 [4a])</li> <li>• <b>Stairs:</b> *Decreased in stance and swing <math>\uparrow</math> and <math>\downarrow</math> stairs compared to no AFO (desired change), <math>P=0.0001</math> (Sienko Thomas 2002 [4a])</li> </ul>	<ul style="list-style-type: none"> <li>• Resistance easily controlled to decrease PF and normalize gait (Yokoyama 2005 [5])</li> </ul>	<ul style="list-style-type: none"> <li>• *Decreased PF at initial contact but not as normal as HAFO. 1/3 patients achieved heel-toe gait, <math>P&lt;0.05</math> (Romkes 2002 [4a])</li> <li>• PF angle at TO normal (desired) (Romkes 2002 [4a]).</li> <li>• “Normalized” during swing (Romkes 2002 [4a]).</li> </ul>	<ul style="list-style-type: none"> <li>• Reduced Equinus (Van Gestel 2008 [4a], Sienko Thomas 2002 [4a], Buckon 2001 [4a])</li> <li>• <b>Stairs:</b> *Decreased in stance and swing <math>\uparrow</math> and <math>\downarrow</math> stairs compared to no AFO (desired change), <math>P=0.0001</math> (Sienko Thomas 2002 [4a])</li> </ul>	<ul style="list-style-type: none"> <li>• *Reduced Equinus, <math>P=0.0001</math> (Sienko Thomas 2002 [4a])</li> <li>• <b>Stairs:</b> *Decreased in stance and swing <math>\uparrow</math> and <math>\downarrow</math> stairs compared to no AFO (desired change) <math>P=0.0001</math> (Sienko Thomas 2002 [4a])</li> </ul>

	<b>Hinged Ankle Foot Orthosis (HAFO)</b>	<b>Hinged Ankle Foot Orthosis (HAFO) Oil Damper with free PF</b>	<b>Supramalleolar Orthosis (SMO)</b>	<b>Posterior Leaf spring Orthosis (PLS)</b>	<b>Solid Ankle Foot Orthosis (SAFO)</b>
<b>Hip Position</b>	<ul style="list-style-type: none"> <li>*Increased hip flexion at IC compared to barefoot and in line with typical “control” group <i>P</i>&lt;0.05 (Romkes 2006 [4a])</li> </ul>			<ul style="list-style-type: none"> <li>• <b>Stairs:</b> *Increased flexion in swing ↑ stairs vs. barefoot or SAFO (desired change), <i>P</i>=0.0009 (Sienko Thomas 2002 [4a])</li> <li>• *Increased extension in stance ↓ stairs when compared to HAFO (desired), <i>P</i>=0.0005 (Sienko Thomas 2002 [4a])</li> <li>• *Decreased flexion in swing ↓ stairs compared to barefoot (desired), <i>P</i>=0.0005 (Sienko Thomas 2002 [4a])</li> </ul>	<ul style="list-style-type: none"> <li>• *Decreased flexion in swing ↓ stairs compared to barefoot (desired), <i>P</i>=0.0005 (Sienko Thomas 2002 [4a])</li> </ul>
<b>Knee Position</b>	<ul style="list-style-type: none"> <li>• In patients with 0-10 ° knee flexion (a desired knee position) or &gt; 10° (crouchers) barefoot, no change at IC or in stance (Buckon 2001 [4a])</li> </ul>	<ul style="list-style-type: none"> <li>• Mild flexion during initial stance phase (Yokoyama 2005 [5])</li> <li>• Decreased hyperextension (Yokoyama 2005 [5])</li> </ul>		<ul style="list-style-type: none"> <li>• In patients with 0-10 ° knee flexion (a desired knee position) barefoot, no change at IC or in stance (Buckon 2001 [4a])</li> </ul>	<ul style="list-style-type: none"> <li>• In patients with 0-10° of flexion in stance barefoot, *decrease in flexion at IC and stance with 7/9 patients hyperextending, (adverse) (Buckon 2001 [4a]).</li> </ul>

	<b>Hinged Ankle Foot Orthosis (HAFO)</b>	<b>Hinged Ankle Foot Orthosis (HAFO) Oil Damper with free PF</b>	<b>Supramalleolar Orthosis (SMO)</b>	<b>Posterior Leaf spring Orthosis (PLS)</b>	<b>Solid Ankle Foot Orthosis (SAFO)</b>
<b>Knee Position</b> <i>(continued)</i>	<ul style="list-style-type: none"> <li>• In patients with knee hyperextension barefoot, *decreased hyperextension during stance phase and no change at IC, <math>P=0.007</math> (Buckon 2001 [4a])</li> <li>• Provided a flexion/extension pattern compared to barefoot (more dynamic) (Romkes 2006 [4a])</li> <li>• *Decreased knee flexion at IC (desired); no change in peak KF during swing or KE during stance compared to barefoot <math>P&lt;0.02</math> (Balaban 2007 [4a])</li> <li>• <b>Stairs:</b> *Decreased extension in stance ↓ stairs, <math>P=0.0005</math> (Sienko Thomas 2002 [4a])</li> <li>• <b>Stairs:</b> *Decreased flexion in swing ↓ stairs <math>P&lt;0.01</math> (Sienko Thomas 2002 [4a])</li> </ul>			<ul style="list-style-type: none"> <li>• In patients with knee flexion <math>&gt;10^\circ</math> (crouchers), PLS approached significant for improving knee extension (Buckon 2001 [4a]).</li> <li>• *Improved knee extension throughout (where it was applicable and desired) <math>P=0.204</math> (Van Gestel 2008 [4a])</li> <li>• <b>Stairs:</b> *More extension in stance ↓ stairs compared to HAFO <math>P=0.003</math> (Sienko Thomas 2002 [4a])</li> <li>• <b>Stairs:</b> *Decreased flexion in swing ↓ stairs <math>P&lt;0.01</math> (Sienko Thomas 2002 [4a])</li> </ul>	<ul style="list-style-type: none"> <li>• In patients with <math>&gt; 10^\circ</math> of flexion in stance barefoot (crouchers), no change in flexion. (Buckon 2001 [4a])</li> <li>• <b>Stairs:</b> *Decreased flexion in swing ↓ stairs <math>P&lt;0.01</math> (Sienko Thomas 2002 [4a])</li> <li>• *"Normalized" kinematics in stance, <math>P&lt;0.001</math> (Thompson 2002 [4a])</li> </ul>

	<b>Hinged Ankle Foot Orthosis (HAFO)</b>	<b>Hinged Ankle Foot Orthosis (HAFO) Oil Damper with free PF</b>	<b>Supramalleolar Orthosis (SMO)</b>	<b>Posterior Leaf spring Orthosis (PLS)</b>	<b>Solid Ankle Foot Orthosis (SAFO)</b>
<b>Outcome Measures</b>					
<b>GMFM</b>	<ul style="list-style-type: none"> <li>• No change on walking, running, jumping dimensions (<i>Buckon 2001 [4a]</i>)</li> <li>• Increased GMFM scores (<i>Morris 2002 [5]</i>)</li> </ul>		<ul style="list-style-type: none"> <li>• Increased GMFM scores (<i>Morris 2002 [5]</i>)</li> </ul>	<ul style="list-style-type: none"> <li>• No change on walking, running, jumping dimensions (<i>Buckon 2001 [4a]</i>)</li> </ul>	<ul style="list-style-type: none"> <li>• No change on walking, running, jumping dimensions (<i>Buckon 2001 [4a]</i>)</li> </ul>
<b>GMPM</b>	<ul style="list-style-type: none"> <li>• *Improvement in quality of motor skills already mastered as measured on the walking, running, jumping dimensions, <math>P &lt; 0.005</math> (<i>Buckon 2001 [4a]</i>)</li> <li>• *Improvement in Coordination and Weight-Shifting scores <math>P &lt; 0.004</math> (<i>Buckon 2001 [4a]</i>)</li> <li>• *Improvements in LE Dissociation Score <math>P = 0.0001</math> (<i>Buckon 2001 [4a]</i>)</li> <li>• No change in measures of alignment and stability scores (<i>Buckon 2001 [4a]</i>)</li> </ul>			<ul style="list-style-type: none"> <li>• *Improvement in quality of motor skills already mastered as measured on the walking, running, jumping dimensions, <math>P &lt; 0.005</math> (<i>Buckon 2001 [4a]</i>)</li> <li>• *Improvement in Coordination and Weight-Shifting scores <math>P &lt; 0.005</math> and <math>P &lt; 0.0001</math> respectively (<i>Buckon 2001 [4a]</i>)</li> <li>• *Improvements in LE Dissociation score, <math>P = 0.0001</math> (<i>Buckon 2001 [4a]</i>)</li> <li>• No change in measures of alignment and stability scores (<i>Buckon 2001 [4a]</i>)</li> </ul>	<ul style="list-style-type: none"> <li>• *Improvement in quality of motor skills already mastered as measured on the walking, running, jumping dimensions, <math>P &lt; 0.005</math> (<i>Buckon 2001 [4a]</i>)</li> <li>• *Improvement in Coordination and Weight-Shifting scores <math>P &lt; 0.005</math> and <math>P &lt; 0.0002</math> respectively (<i>Buckon 2001 [4a]</i>)</li> <li>• No change in LE Dissociation Score (<i>Buckon 2001 [4a]</i>)</li> <li>• No change in measures of alignment and stability scores (<i>Buckon 2001 [4a]</i>)</li> </ul>
<b>PEDI</b>	<ul style="list-style-type: none"> <li>• *Improvement in functional skill scores <math>P &lt; 0.004</math> (<i>Buckon 2001 [4a]</i>)</li> </ul>			<ul style="list-style-type: none"> <li>• *Improvement in functional skill scores, <math>P &lt; 0.004</math> (<i>Buckon 2001 [4a]</i>)</li> </ul>	<ul style="list-style-type: none"> <li>• *Improvement in functional skill scores, <math>P &lt; 0.004</math> (<i>Buckon 2001 [4a]</i>)</li> </ul>

	<b>Hinged Ankle Foot Orthosis (HAFO)</b>	<b>Hinged Ankle Foot Orthosis (HAFO) Oil Damper with free PF</b>	<b>Supramalleolar Orthosis (SMO)</b>	<b>Posterior Leaf spring Orthosis (PLS)</b>	<b>Solid Ankle Foot Orthosis (SAFO)</b>
<b>PEDI (Other items)</b>	<ul style="list-style-type: none"> <li>Increased; did not reach significance; children able to keep up with peers on stairs improved from 32-67% to ascend and 26-53% to descend (Sienko Thomas 2002 [4a])</li> </ul>			<ul style="list-style-type: none"> <li>Increased; did not reach statistical significance; children able to keep up with peers on stairs improved from 32-42% to ascend and 26-32% to descend (Sienko Thomas 2002 [4a])</li> </ul>	<ul style="list-style-type: none"> <li>Increased; did not reach statistical significance; children able to keep up with peers on stairs improved from 32-47% to ascend and 26-37% to descend (Sienko Thomas 2002 [4a])</li> </ul>

<b>Abbreviation Key</b>	
<b>DF</b> = dorsiflexion	<b>PEDI</b> = Pediatric Evaluation of Disability Inventory
<b>GMFM</b> = Gross Motor Function Measure	<b>PLS</b> = posterior leaf spring
<b>GMPM</b> = Gross Motor Performance Measure	<b>ROM</b> = range of motion
<b>HAFO</b> = hinged ankle foot orthosis	<b>SAFO</b> = solid ankle foot orthosis
<b>IC</b> = initial contact	<b>SMO</b> = supramalleolar orthosis
<b>LE</b> = lower extremity	<b>TO</b> = toe off
↑ = ascending	↓ = descending
<b>* Indicates statistically significant change</b>	