Why Prescribe a Rigid AFO Unless You Have To?

Challenging the Fundamental Design of AFO's

MR SIMON B DICKINSON

ORTHOTIST

Problem Solving

AFO Prescription

- Huge variation in historical AFO prescribing practice
- Move towards evidence based practice
- Rigid AFO's have become Gold Standard
- What do we know about effects of rigid AFO's?
- What do we think we know?
- What don't we know?
- What features of Rigid AFO prescription might be problematic?
- Are we providing patients with what they want or what we think they want?
- Can we do better?

1990's AFO Innovation's

Hinged AFO's

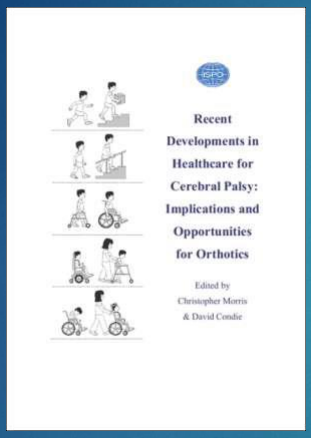
DAFO's

Journal of Prosthetics and Orthotics, Volume 2, Number 1, pp. 48-53

Postural and Functional Impact of Dynamic AFOs and FOs in a Pediatric Population

Nancy M. Hylton, R.P.T

ISPO Consensus meeting 8-11 Sept 2008



- Morris C, Condie DN (eds) 2008
- ISBN 87-89809-28-9
- Downloadable from www.ispoint.org

24 individuals
- 12 reviewers
- 9 discussants

International
- 7 countries

Multidisciplinary
- Health care professionals
- Physicians
- Surgeons
- Therapists
- Orthotists
- Research scientists

A REVIEW OF THE EFFECTIVENESS OF LOWER LIMB ORTHOSES USED IN CEREBRAL PALSY

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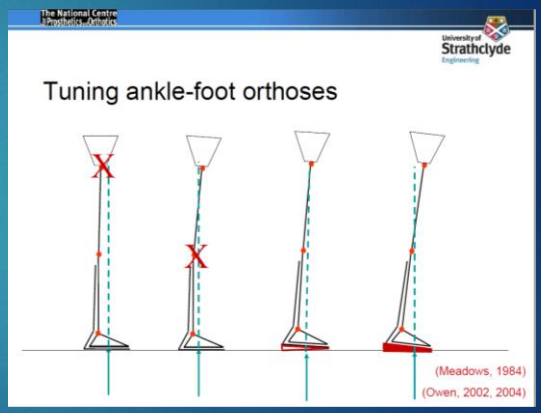
&
Karyn Ross BSc Prosthetist & Orthotist
National Centre for Prosthetics and Orthotics,
University of Strathclyde, Glasgow, UK

To produce this review, a systematic literature search was conducted for relevant articles published in the period between the date of the previous ISPO consensus conference report on cerebral palsy (1994) and April 2008. The search terms were "cerebral and pals* (palsy, palsies), "hemiplegia", "diplegia", "orthos*" (orthoses, orthosis) orthot* (orthotic, orthotics), brace or AFO. Papers were selected for review if they addressed the use of lower limb orthoses in cerebral palsy. Papers relating to adult onset pathology were rejected. Papers relating to the direct application of hip orthoses were excluded as this area is addressed in a separate review on the effects of orthoses on the hips, spine and upper limbs. Abstracts were rejected if their content was subsequently located in full research papers. Only English language papers were included. Databases searched were EMBASE (ovid), Science Direct, social services abstracts, psychINFO, Medline (ovid), APAIS Heath (informit), AMI, Cinahl, PubMed, Recal, the NHS Scotland e-library and Google Scholar. The literature review on orthotic management of cerebral palsy by Morris [1] was also consulted.

Current Evidence: Rigid AFO Set Up

- Evidence based criteria for Rigid AFO tuning
  - Ankle position
  - Shank Alignment
  - Tuning- footwear mods
  - Kinematics
- Validated in Gait Labs



What else do we know about Rigid AFO's (compared to impaired barefoot walking for children with CP) ?

Good

- Improve walking speed (enhanced with Botox?)
- Reduce cadence
- Improved Stride length
- Single support prolonged
- Improve ankle, knee & hip kinematics
- No effect on pelvis
- Improve foot alignment
- Tuning very important
- Botox can compliment orthotic treatment and improve outcomes further

Bad

- AFO's that restrict ankle joint motion reduce power generation and absorption at the ankle
  - Is this an acceptable compromise in order to optimise other gait parameters?

What we think we know about Rigid AFO's (compared to impaired barefoot walking for children with CP)?

- Positive influence on metabolic cost of walking
- A minimum of 6 hours of corrected positioning a day changes resistance to passive stretch and decreased tone in Soleus
- Improve standing balance

What we don't know about Rigid AFO's (compared to impaired barefoot walking in children with CP) ……

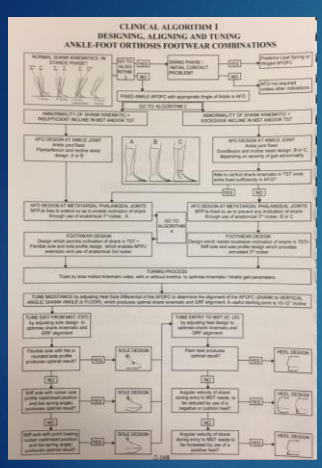
How do they effect…

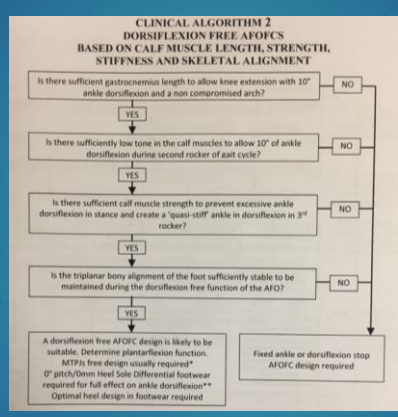
- Phasic muscle activity
- Muscle Strength
- Sit to Stand (STS)
- Stairs?
- Uneven Ground?
- Neuroplasticity impact
- Impact on Ankle ROM
- Foot alignment in the growing child
- What impact does stabilising the knee artificially (by moving GRF in front of the knee and behind the hip) have on motor learning/co-ordination and strength
- Can we deliver similar kinematic results using hinged afo's with motion control

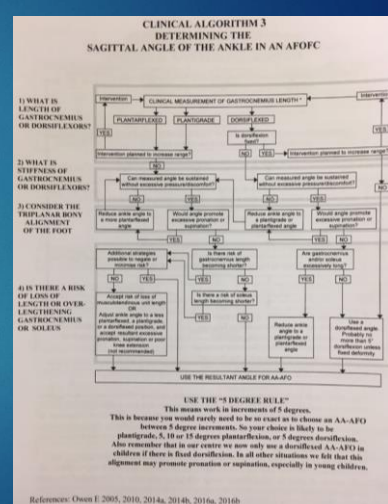
What do we know about Hinged AFO's (compared to impaired barefoot walking for children with CP) ?

- Stride length better in Hinged AFO's than Rigid AFO's
- Free ankle dorsiflexion AFO's (with plantarflexion stops) at 90 degrees can cause crouch gait in presence of gastrosoleus tightness and spasticity
- Hinged AFO's must block ankle motion at appropriate angles so the GRF vector can be successfully manipulated
- STS likely to be easier in hinged AFO

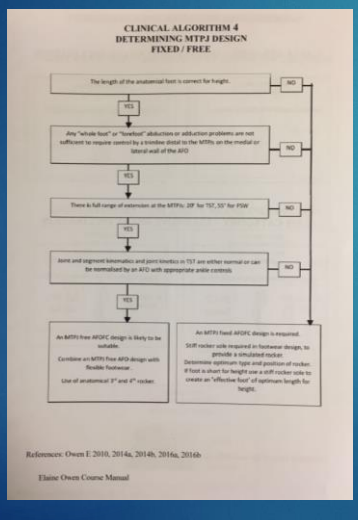
CP AFO Algorithms- Elaine Owen

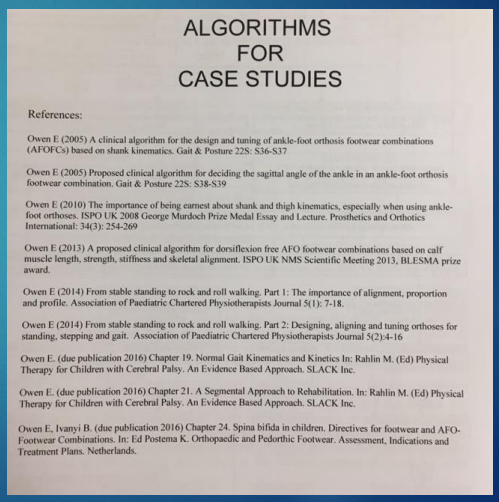






CP AFO Algorithms (cont)





ALGORITHMS
FOR
CASE STUDIES

References:

Owen E (2005) A clinical algorithm for the design and tuning of ankle-foot orthosis footwear combinations (AFOFCs) based on shank kinematics. Gait & Posture 22S: S36-S37

Owen E (2005) Proposed clinical algorithm for deciding the sagittal angle of the ankle in an ankle-foot orthosis footwear combination. Gait & Posture 22S: S38-S39

Owen E (2010) The importance of being earnest about shank and thigh kinematics, especially when using ankle-foot orthoses. ISPO UK 2008 George Murdoch Prize Medal Essay and Lecture. Prosthetics and Orthotics International: 34(3): 254-269

Owen E (2013) A proposed clinical algorithm for dorsiflexion free AFO footwear combinations based on calf muscle length, strength, stiffness and skeletal alignment. ISPO UK NMS Scientific Meeting 2013, BLESMA prize award.

Owen E (2014) From stable standing to rock and roll walking. Part 1: The importance of alignment, proportion and profile. Association of Paediatric Chartered Physiotherapists Journal 5(1): 7-18.

Owen E (2014) From stable standing to rock and roll walking. Part 2: Designing, aligning and tuning orthoses for standing, stepping and gait. Association of Paediatric Chartered Physiotherapists Journal 5(2):4-16

Owen E. (due publication 2016) Chapter 19. Normal Gait Kinematics and Kinetics In: Rahlin M. (Ed) Physical Therapy for Children with Cerebral Palsy. An Evidence Based Approach. SLACK Inc.

Owen E. (due publication 2016) Chapter 21. A Segmental Approach to Rehabilitation. In: Rahlin M. (Ed) Physical Therapy for Children with Cerebral Palsy. An Evidence Based Approach. SLACK Inc.

Owen E, Ivanyi B. (due publication 2016) Chapter 24. Spina bifida in children. Directives for footwear and AFO-Footwear Combinations. In: Ed Postema K. Orthopaedic and Pedorthic Footwear. Assessment, Indications and Treatment Plans. Netherlands.

Thoughts

- Rigid AFO tuning and validation of tuning is robust and necessary for CP patients on Flat surfaces
- What impact do rigid AFO's have on CP children function outside the gait lab(e.g. STS, Stairs, Uneven ground, slopes, ADL's, social inclusion)?
- Why do so many children with CP stop wearing their AFO's at home/away from school?
- Are "idealised" kinetics successful outcomes from a patients perspective
- Are these results transferable to other Neurological conditions?
- Can we achieve similar or better results with different AFO designs (as technologies improve)?

What has happened since 2008?

- More research and guidelines promoting Shank inclined rigid AFO's kinematics
- NHS Quality Improvement Scotland Best practice statement- Use of ankle-foot orthoses following stroke

Summary:

Biomechanical effects of AFOs

- an AFO can positively influence the alignment and motion of the foot and ankle in stance and in swing
- the use of an AFO can have a positive effect on the motion and alignment of the knee and hip joints in stance
- an AFO can have a positive effect on the temporal and spatial parameters of gait (eg velocity, cadence, step length)
- contracture management should be considered to enhance the effectiveness of an AFO, and
- management of tone and/or spasticity should be considered to enhance the effectiveness of an AFO.

Non-biomechanical effects of AFOs

- the ultimate aim of using AFOs with people who have had a stroke is to improve mobility and quality of life
- quality of life indicators should be used to assess treatment outcomes in stroke rehabilitation
- appropriate intervention with an AFO can improve/facilitate increased independence of patients following stroke, and
- using AFOs to facilitate independent ambulation can have beneficial psychological effects.

AFO design indications

Indications for different AFOs

1) Posterior leaf spring

Figure 3: Custom-made PLS

This flexible orthosis is similar to many prefabricated AFOs designs, and can be made from a range of materials (Figure 3). The PLS AFO is only indicated in cases where there is isolated dorsiflexor weakness, ie simple swing phase problems (drop foot). It is not appropriate when there is any significant problem of high tone or spasticity, any significant mediolateral instability of the foot, or the need for orthotic influence on the knee and/or the hip[2, 12]. These very specific prescription criteria will exclude many stroke patients, who have increased tone, supination of the foot, knee hyperextension, and/or hip flexion and retraction.

2) Hinged or articulated AFO

Figure 4: Hinged AFO

There are a number of mechanical ankle joints which may be incorporated into HAFOs to allow or assist motion in one direction while preventing or limiting motion in another (Figure 4). Typically, hinged AFOs block plantarflexion at 90°. A HAFO that allows dorsiflexion should only be considered when an adequate range of dorsiflexion is already present. Specifically, there should be adequate length in the gastrocnemius to allow approximately 10° dorsiflexion with the knee fully extended[12, 14]. It is important that this range of dorsiflexion should be achievable without any spastic catch in the plantarflexors[15, 16], and without undue resistance due to tone. Even if adequate dorsiflexion range is present, HAFOs may be inappropriate in the presence of moderate to severe mediolateral instability of the foot. This is because the space needed for the ankle joints makes HAFOs fit less well than solid ankle designs.

3) Solid AFO

Figure 5: Solid AFO

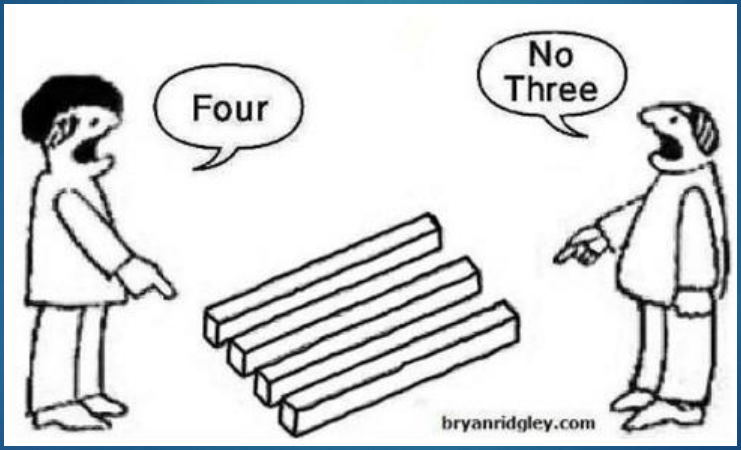
Solid AFOs prevent all motion at the foot and ankle (Figure 5). They are indicated when there is high tone or spasticity in the plantarflexors, a gastrocnemius contracture, significant mediolateral instability of the foot and/or a need for the AFO to influence the knee or hip[2, 12]. The stiffness of a solid AFO is influenced by material choice and thickness, and the location of the trim lines (edges) which should be anterior to the malleoli. Reinforcements (eg carbon fibre inserts) may be incorporated at the ankle section of a solid AFO to increase stiffness. Flexing, or 'buckling', of the AFO should not be tolerated as a way of allowing stance phase progression, as this will compromise mediolateral control of the foot. Instead, stance phase progression can be improved by 'tuning' the solid AFO, a process which is essential to optimise the alignment of the ground reaction force (GRF) vector to the knee and hip joints[12, 14] (see Appendices 6 and 7).

4) Ground reaction orthosis

Figure 6: Floor reaction AFO

A GRAFO is a form of solid AFO which is designed to maximise the indirect orthotic control of knee flexion during stance phase (Figure 6). To have this effect on the knee, a GRAFO must be very stiff and must be optimally aligned so as to ensure that the ground reaction force is in front of the knee in mid to late stance, generating an external knee extension moment[14] (see Appendices 3 and 6). A specific design feature of the GRAFO is a plastic pretibial shell close to the knee, which helps prevent excessive tibial progression. Fixed deformity in any of the three anatomical planes (see Appendix 2) or the presence of dynamic contracture of the knee and/or hip will compromise the effectiveness of a GRAFO.

Kinetics vs Kinematics



Understanding the problem…..

"Science is beautiful when it makes simple explanations of phenomena or connections between different observations. Examples include the double helix in biology and the fundamental equations of physics"

Professor Stephen Hawking 2017

Neuroplasticity……

Neuroplasticity is the brain's ability to "rewire" or reorganise itself

- Neuroplastic "loops" are maintained by repetition of movement
- The intact (non-injured) brain has the capacity and ability to learn
- Task specific movements promotes neuroplasticity
- FES has been shown to promote neuroplasticity
- Rigid AFO's have the potential to inhibit Neuroplasticity by immobilising the ankle

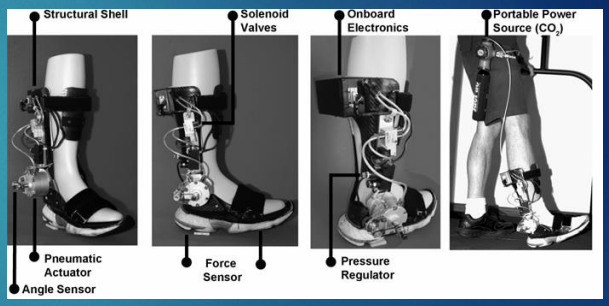
Why do we rarely use hinged AFO's in CP and Stroke Rehab?

- Free dorsiflexion AFO's do not adequately control GRF
- Limited Motion AFO's have potential to control GRF
- Hinged AFO's s allow some ankle motion which is an essential driver for neuroplasticity
- **So why would we ever stop an ankle joint moving unless we had to?**

How could we design AFO's for neuro rehab differently?

Possible options

- Controlled Motion
- Motion Assistance
- Motion Resistance
- Shank inclination?
- Integrated FES/AFO hybrids
- Intelligent powered AFO's



Ottobock Motion Control Ankle Joint

Multifunctional Ankle Joint

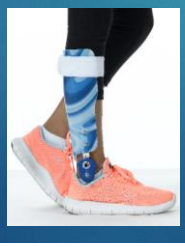
17B66=A-16

- 9 different setting options
- ROM control with varying degrees of spring assist
- Springs Assist Motion

Fior & Gentz Motion Control ankle Joint

- Neuro Swing
- Available in 5 sizes
- Waterproof version
- Shank Alignment adjust
- ROM control
- Adjustable springs assist movement
- Can be used single/double sided

Becker Motion Control Ankle Joint



- Triple Action
- Male Adult and paediatric version
- Independent shank alignment adjust
- ROM control
- Varying Springs resist motion (not assist)

Double Action – Theory of Operation

- The resistance and alignment functions are linked through the stirrup and are **interdependent.**
- Orthotic tuning is a trial and error process.

Double Action Ankle Joint

Adult Triple Action®

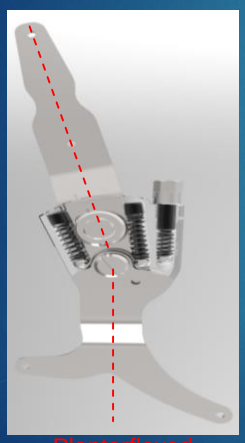
2nd Rocker Dorsiflexion Resist Channel (Not Adjustable)

Terminal Stance Dorsiflexion Resist Channel (Adjustable)

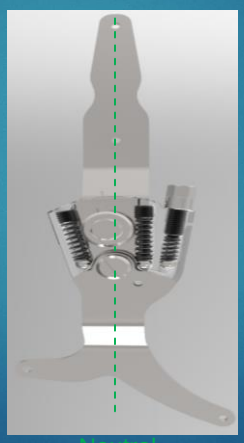
Plantarflexion resist channel

Adult Triple Action® – Alignment

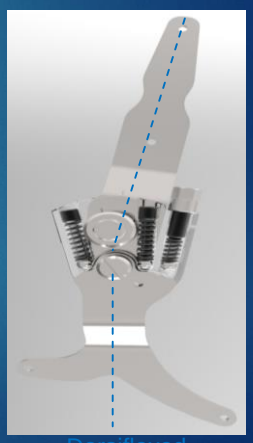
- The alignment does not influence the resistance functions.
- The component body is rotated about the pivot bushing by the alignment cam.



Plantarflexed



Neutral



Dorsiflexed

Shank alignment adjust

Treatment Algorithm

Alignment positions the foot for swing and initial contact

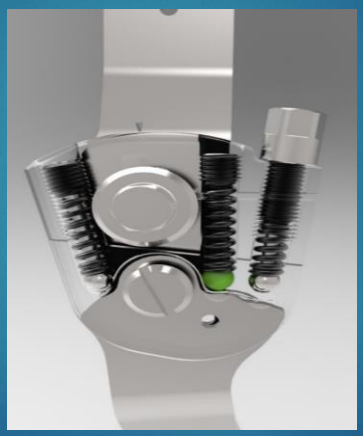
PF resist influences first rocker and knee flexion/extension in early stance

DF resist stabilizes the knee in late stance and may help initiate swing phase

Adult Triple Action® – Staged Resist

PF and DF resist are isolated and independently adjustable.

Plantarflexion Resist

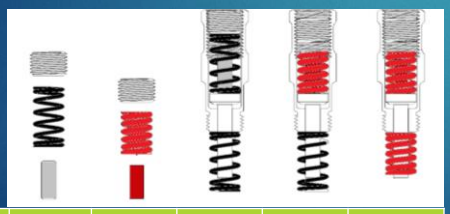


Dorsiflexion Resist

Dorsiflexion Resist

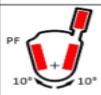
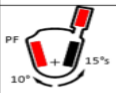
Pediatric Triple Action® – Spring Options

With the addition of the optional Booster Spring Staged Resist Adapter, springs may be combined in 5 unique configurations.



Spring No.	1	2	3	4*	5

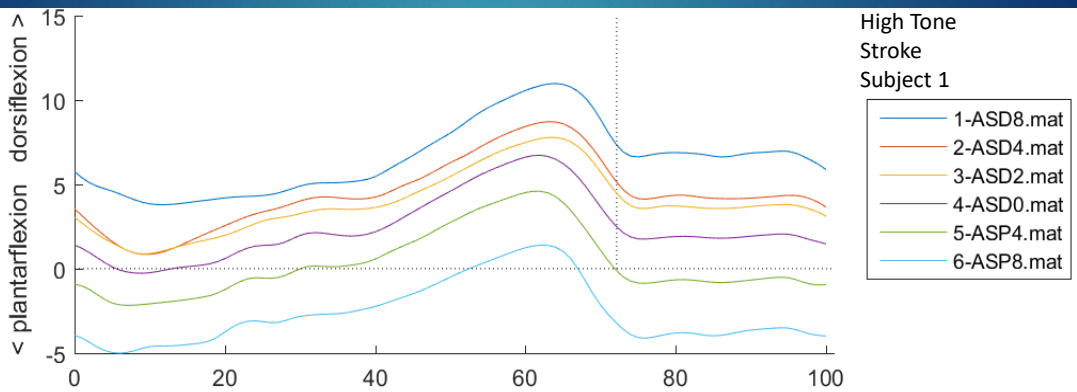
Tuning Procedure: Spring Selection

Gait Type*	Pattern	Orthotic Design	Mild to Moderate	Moderate to Severe
Gait Type 1: Hemiparesis with drop foot in swing phase secondary to dorsiflexion insufficiency. No significant triceps surae contracture.		Posterior tibial section. Sulcus length footplate.		
Gait type 2: Hemiparesis with dropfoot and true equinus secondary to triceps surae contracture, with or without genu recurvatum.		Posterior tibial section. Sulcus length footplate.		
Gait type 3: Hemiparesis with true equinus. Jump gait with contracture or spasticity of gastrosoleus. Spastic co-contraction of quadriceps and hamstrings.		Anterior tibial section. Full length footplate.		
Gait type 4: Hemiparesis gait type 3 plus hip flexor/adductor spasticity.		Anterior tibial section. Full length footplate.		
Crouch Gait: Diplegia with excessive dorsiflexion, knee and hip flexion.		Anterior tibial section. Full length footplate.		

*Gait Type from "Classification of gait patterns in spastic hemiplegia and spastic diplegia: a basis for a management algorithm". Rodda et al. 2001.

Research

These studies have demonstrated the systematic influence of Triple Action on ankle and knee kinematics, kinetics and power.



Clinical Impact – MS Case Study

Clinical Presentation 2007

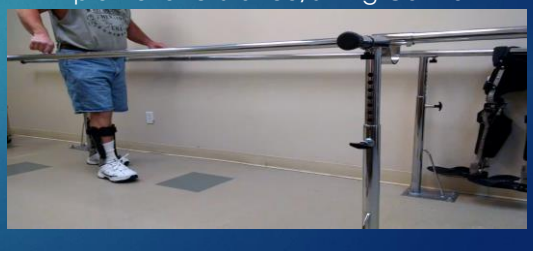
KAFO

Safety Stride® Stance Control

Clinical Presentation 2017

AFO

Triple Action® Stance/Swing Control



Maximising function

Maximising Function

Moving Forward

- All Orthoses have advantages and disadvantages
- Can we improve our designs to maximise function and recovery?
- Do patients need different orthoses for different activities?
- Are we providing patients with what they want (or what we think they need)?
- Research on functional impact of AFO's outside of Gait labs is desperately needed
- Does controlled frequent ankle motion have the potential to reduce spasticity, influence catch,improve ROM and create opportunity for Neuroplasticity?

Summary

- Interventions for drop foot need to deliver functional results outside of a clinic room
- Why limit ankle movement unless you have to?

Thank you for listening…….