Lower extremity orthosis from standing to walking period

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Importance of Foot and Ankle

More dysfunction in distal than proximal joint (CNS pathology)

Unstable foot induces additional alignment abNL at the hip and knee

Significant hip and knee flexion contracture cannot be corrected by use of orthoses

- Orthotic management is primarily directed toward compensating for foot and ankle dysfunction

- Ankle-Foot Orthosis (AFO)

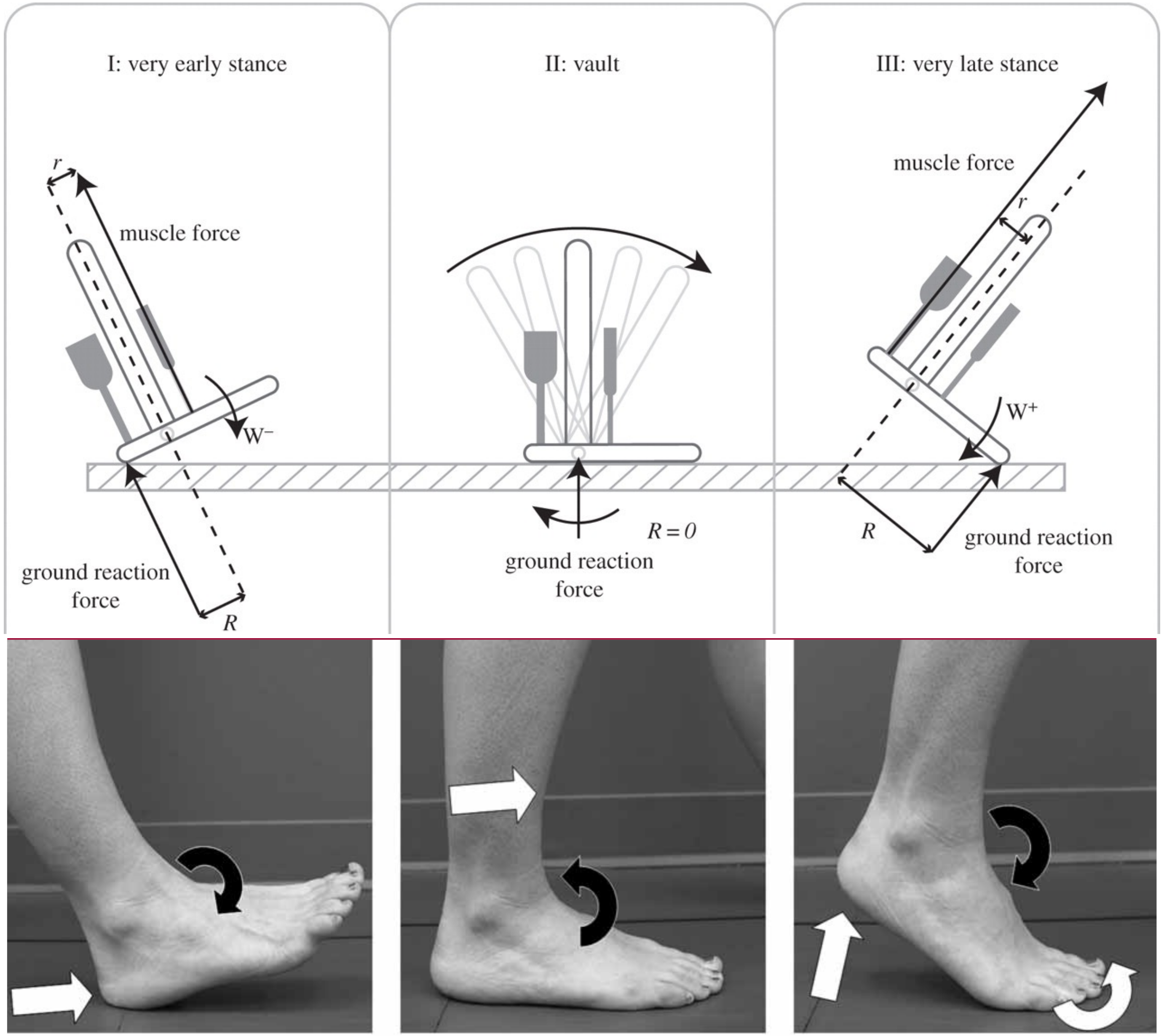
Normal foot and ankle mechanism during gait

Three rockers

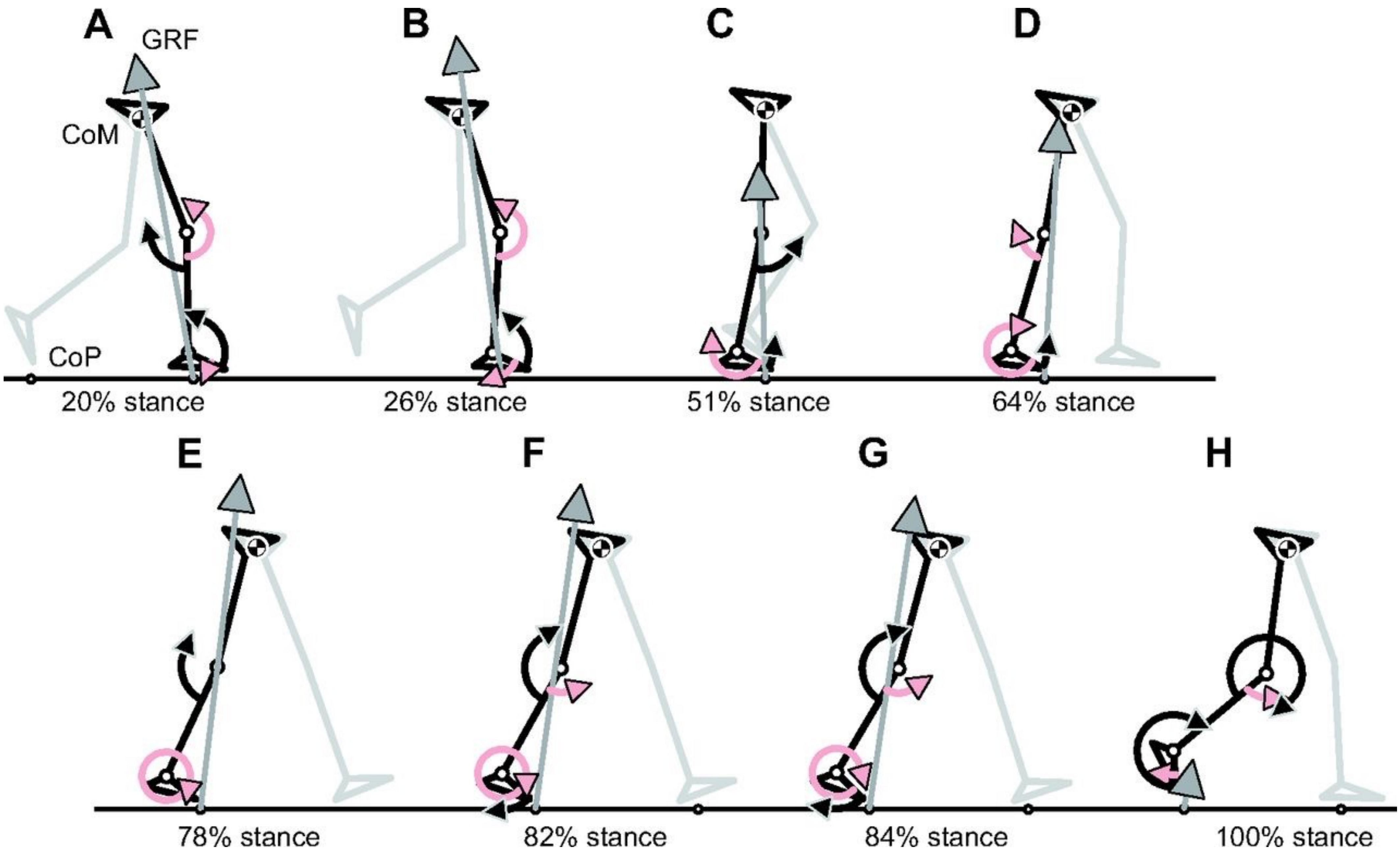
Heel rocker

Ankle rocker

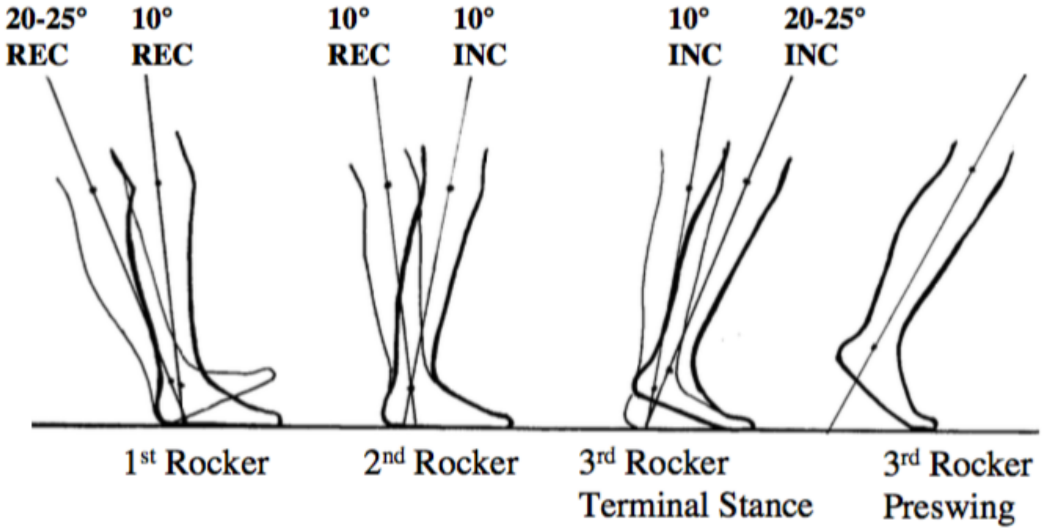
Forefoot rocker

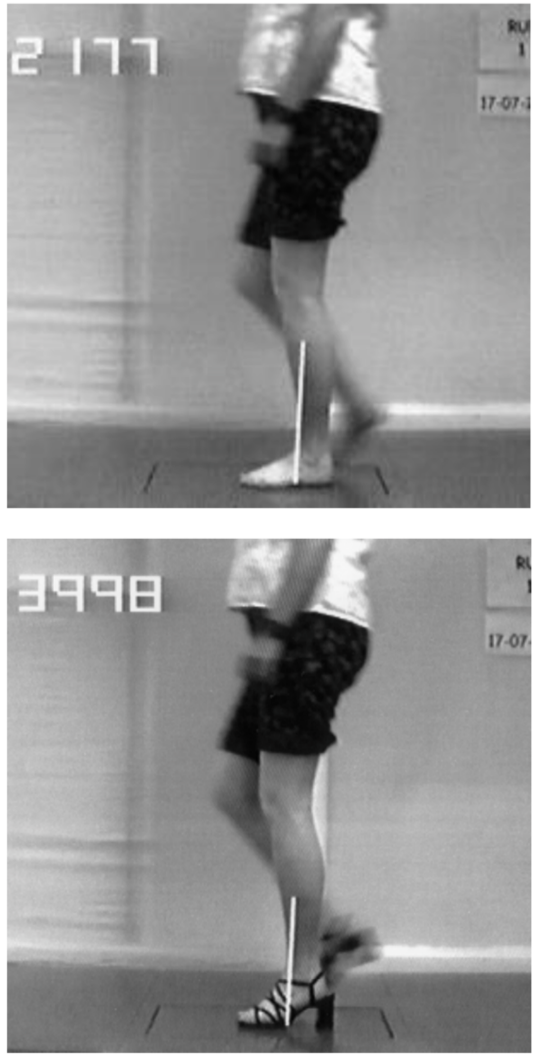


Ground reaction force during gait



Kinematic of shank





Ankle-Foot Orthosis (AFO)

Progression of foot deformity in spastic CP

Equinus

Equinovarus

Equinovalgus

Planovalgus

Purposes of AFO

Improve gait

Prevent the development and worsening of deformities with growth

&

Protect the outcome of surgical procedure during healing and rehabilitation

Purposes of AFO

Pes equinus

- platigrade foot for normal gait mechanism and more stability during gait
- **improve** gait function

Pes equinovalgus, planovalgus

- prevent shortening of triceps surge
- correction of midfoot and hindfoot deformities
- **minimize** progressive deformities with growth

Improve gait function

Effect of AFO

Kinematic : ankle DF ⬆

Kinetic : abnormal ankle PF moment during loading response ⬇

Temporospatial : cadence ⬇, step length ⬆, velocity⬆

Energy expenditure ⬇

Pediatr phys ther 2008;20:207-223

appropriate AFO design

solid

hinged

ground reaction

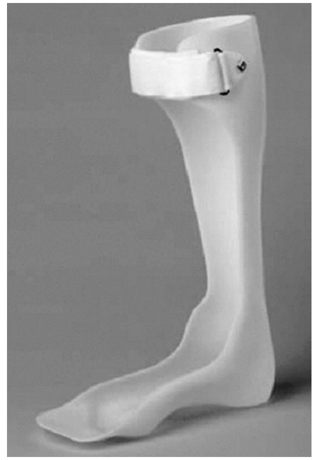
appropriate AFO design


Heel rocker


Ankle rocker



Forefoot rocker



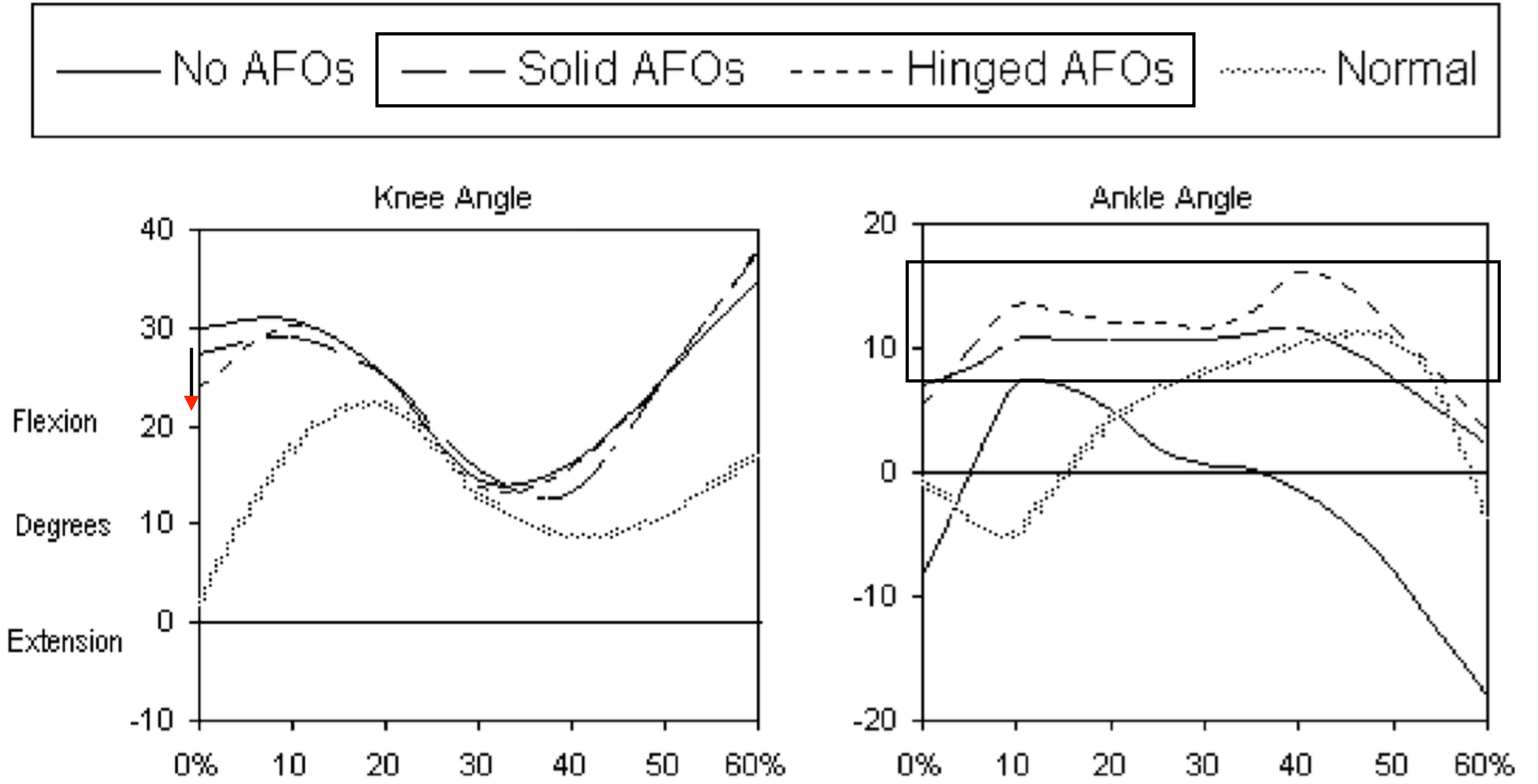
No rocker

Hinged vs Rigid

Article	No. of Subjects	Characteristics of Sample	Orthosis	Analysis	Results
Buckon et al[16]	16	Spastic diplegia	Rigid, articulated and posterior leaf spring	Gait analysis: kinetics, kinematics, and gait parameters	No significant differences in gait parameters No change in kinetics or kinematic of pelvis and hip No significant difference in degree of knee extension at initial contact Increase in peak dorsiflexion with articulated orthosis
Rethlefsen et al[19]	15	Spastic diplegia	Rigid and articulated	Gait analysis: kinetics, kinematics, and gait parameters	Improved bipedal support and shorter unipedal support with articulated orthosis No significant difference in degree of knee extension at initial contact No difference in peak dorsiflexion
Rethlefsen et al[20]	12	Spastic diplegia	Rigid and articulated	Gait analysis: kinetics, kinematics, and gait parameters	Increase in peak dorsiflexion with articulated orthosis No significant difference in degree of knee extension at initial contact
Radtka et al[17]	12	Spastic diplegia	Rigid and articulated	Gait analysis: kinetics, kinematics, gait parameters, and electromyography	No significant differences in gait parameters or muscle activity in different phases Increase in peak dorsiflexion with articulated orthosis No significant difference in degree of knee extension at initial contact
Smiley et al[18]	14	Spastic diplegia	Rigid, articulated, and posterior leaf spring	Gait analysis: kinetics, kinematics, gait parameters, and energy expenditure	No significant differences in gait parameters, kinetics, kinematics or energy expenditure
Rethlefsen et al[20]	21	Spastic diplegia	Rigid and articulated	Gait analysis: kinetics, kinematics, and gait parameters	Increase in peak dorsiflexion with articulated orthosis No significant difference in range of motion of knee
Buckon et al[22]	30	Spastic hemiplegia	Rigid, articulated, and posterior leaf spring	Gait analysis: kinetics, kinematics, gait parameters, and energy expenditure	Increase in peak dorsiflexion with articulated orthosis Significant increase in gait velocity with articulated orthosis Reduction in energy expenditure with articulated orthosis

(Pediatr Phys Ther 2012;24:308–312)

Hinged vs Rigid



Gait and Posture 21 (2005) 303–310

selection of Ankle angle

Shortness of tri-jointed (knee, ankle & subtalar) **GCM** musculotendinous unit

less plantarflexion and excessive dorsiflexion

➡ Excessive tibial progression during loading response

➡ taken up <u>too much at ankle and subtalar joints</u>

➡ **insufficient** length at **knee** joint to allow extension during midstance, terminal stance and terminal swing phase

selection of Ankle angle

Shortness of tri-jointed **GCM** musculotendinous unit

less plantarflexion and excessive dorsiflexion

➡ **overstretch** of sarcomere

➡ **insufficient** power production, esp. for concentric contraction

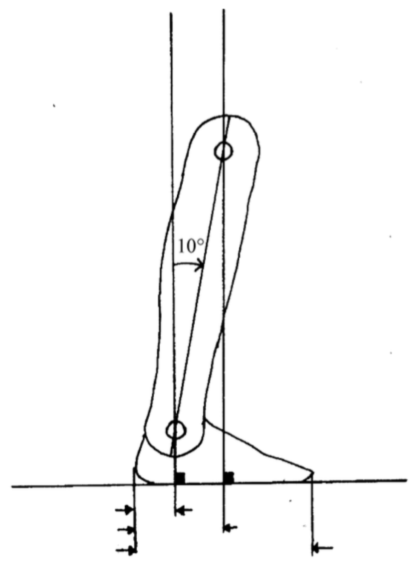
Appropriate shank inclination

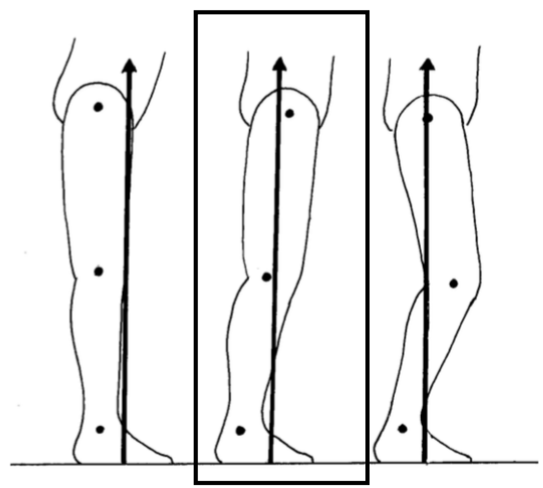
about 10 degrees

normal shank inclination before heel lift

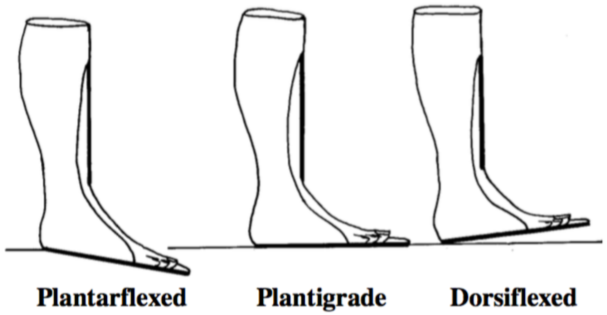
knee joint center over the middle of the foot

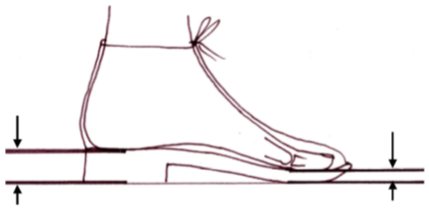
knee vs. hip extension moment

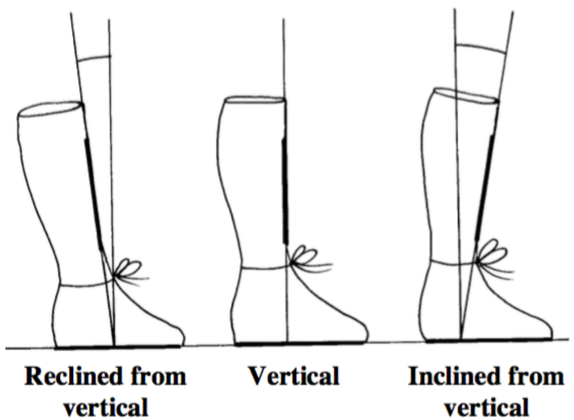


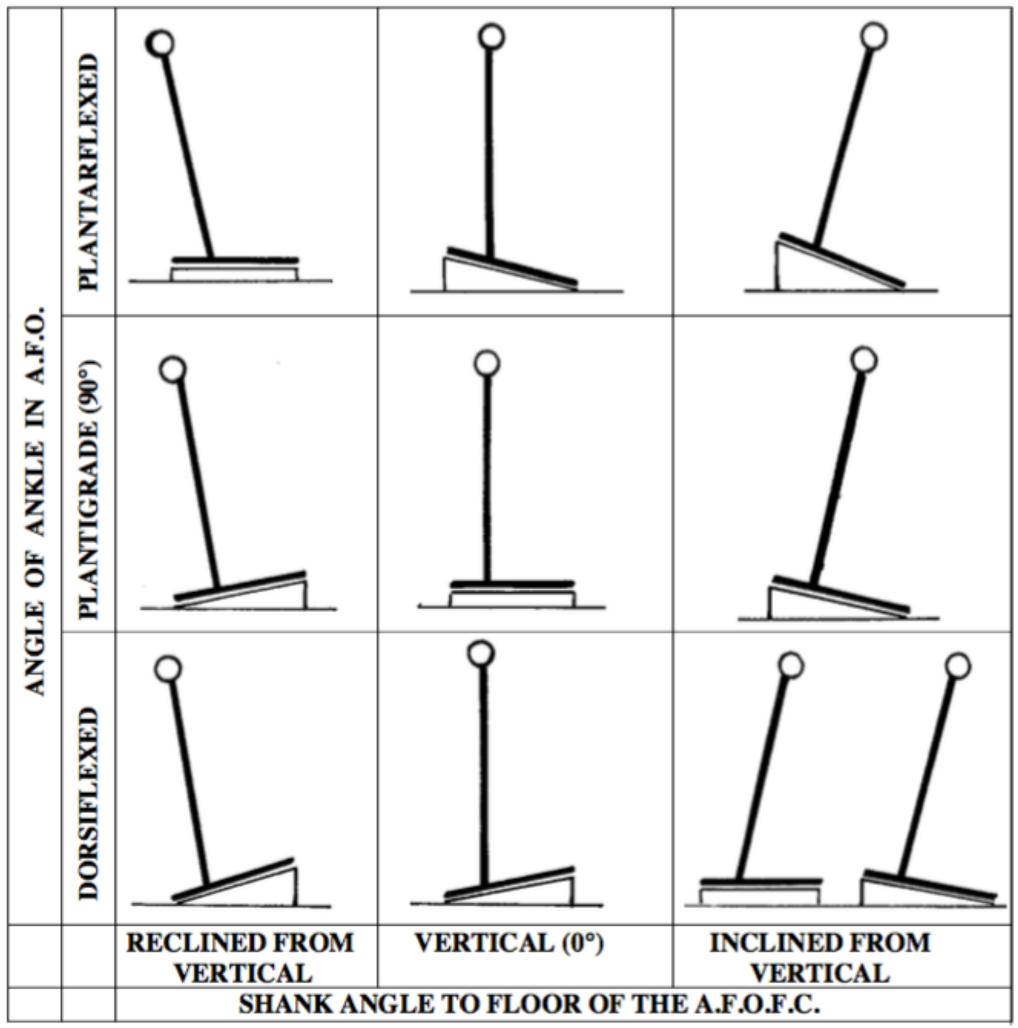


Ankle angle of AFO &
Shank angle of AFO-shoe combination

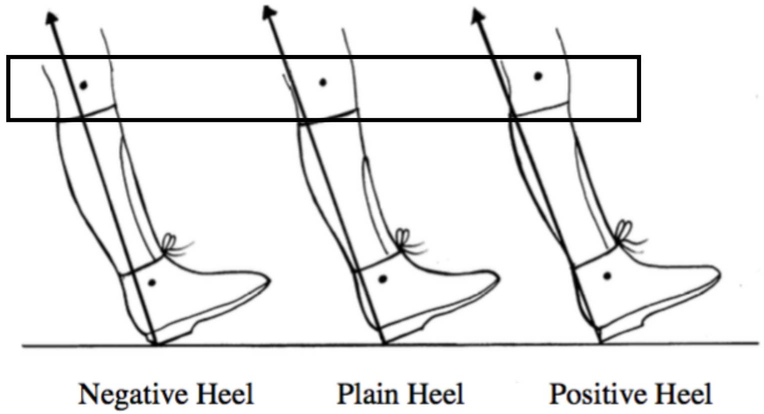


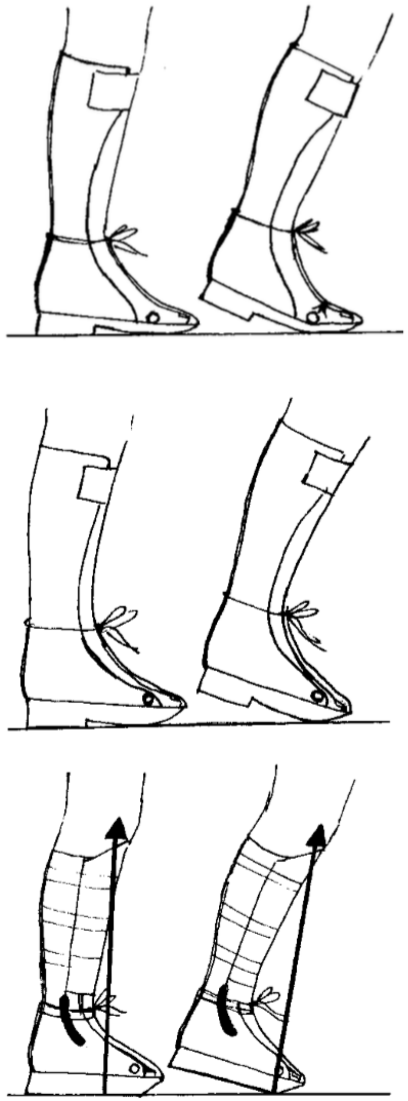






Sole & Heel design





flexible, flat

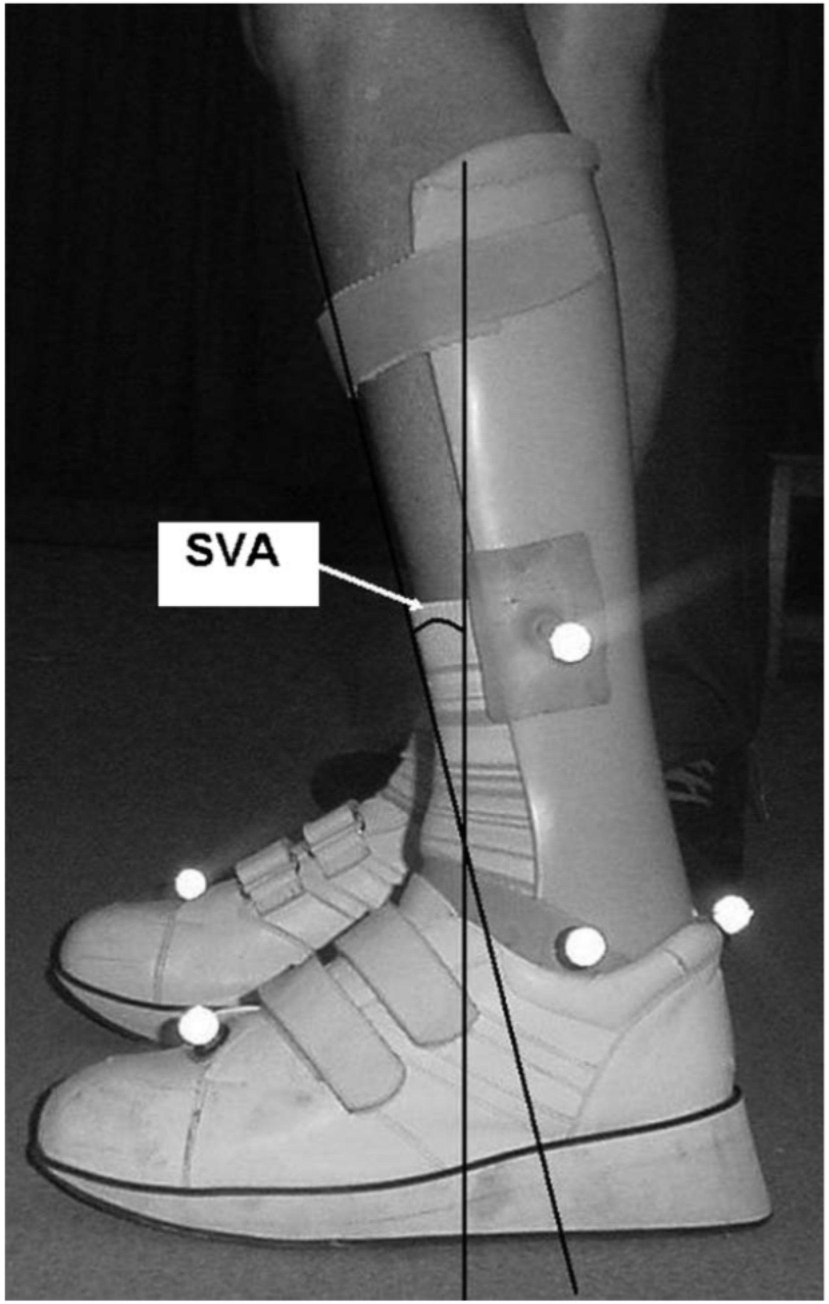
stiff, rounded

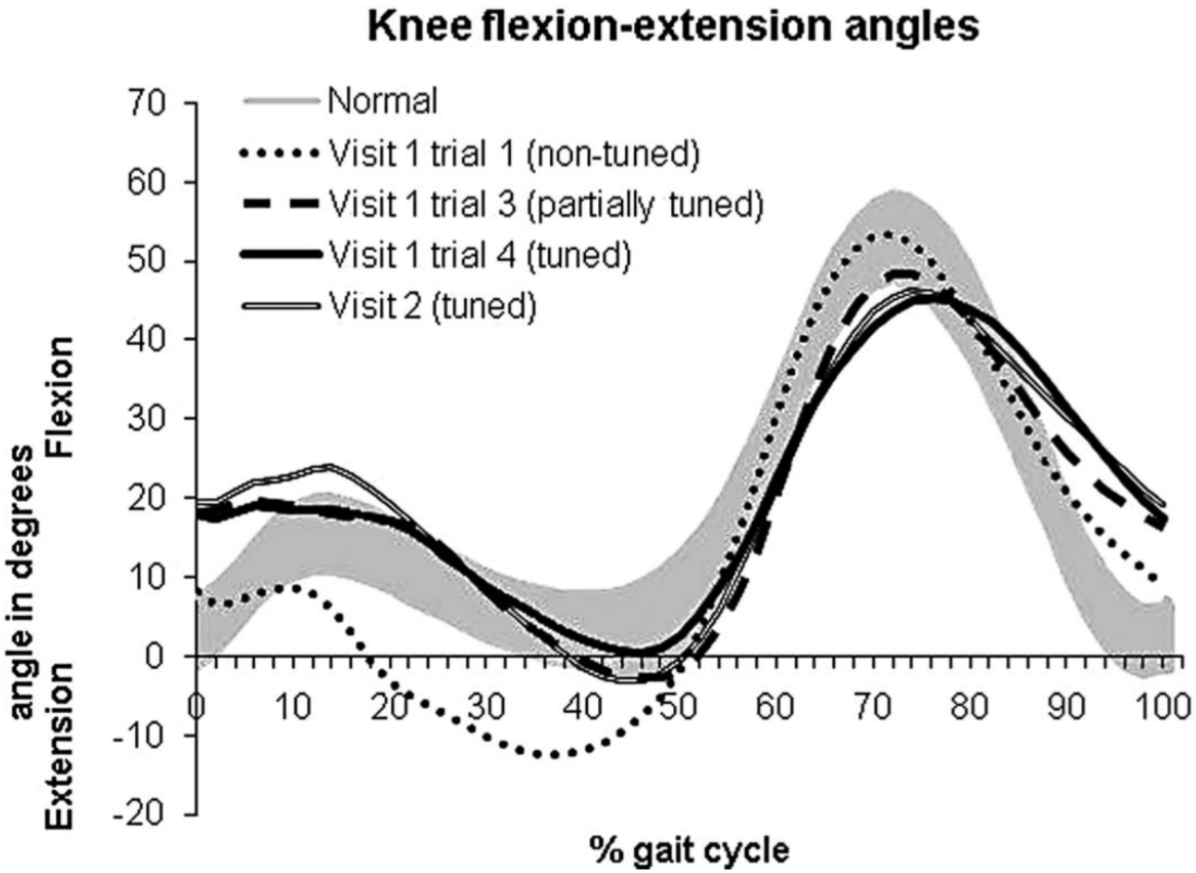
stiff, point-loading

Heel rocker

Forefoot rocker

The effects of tuning an Ankle-Foot Orthosis Footwear Combination on kinematics and kinetics of the knee joint of an adult with hemiplegia





Prosthetics and Orthotics International
September 2010; 34(3): 270–276

Minimize progressive deformities with growth

Prevent shortening of triceps surge

[Intervention Review]

Stretch for the treatment and prevention of contractures

Owen M Katalinic[1], Lisa A Harvey[2], Robert D Herbert[3], Anne M Moseley[3], Natasha A Lannin[1], Karl Schurr[4]

[1]Rehabilitation Studies Unit, Northern Clinical School, Sydney Medical School, The University of Sydney, Ryde, Australia. [2]Rehabilitation Studies Unit, Northern Clinical School, Sydney Medical School, The University of Sydney, Ryde, Australia. [3]The George Institute for International Health, Sydney, Australia. [4]Physiotherapy Department, Bankstown Hospital, Bankstown, Australia

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Editorial group: Cochrane Musculoskeletal Group.
Publication status and date: New, published in Issue 9, 2010.
Review content assessed as up-to-date: 14 April 2009.

Main results

Thirty-five studies with 1391 participants met the inclusion criteria. No study performed stretch for more than seven months. In people with neurological conditions, there was moderate to high quality evidence to indicate that stretch does not have clinically important immediate (mean difference 3 °; 95% CI 0 to 7), short-term (mean difference 1 °; 95% CI 0 to 3) or long-term (mean difference 0 °; 95% CI -2 to 2) effects on joint mobility. The results were similar for people with non-neurological conditions. For all conditions, there is little or no effect of stretch on pain, spasticity, activity limitation, participation restriction or quality of life.

Authors' conclusions

Stretch does not have clinically important effects on joint mobility in people with, or at risk of, contractures if performed for less than seven months. The effects of stretch performed for periods longer than seven months have not been investigated.

Stretching with Children with Cerebral Palsy: What Do We Know and Where Are We Going?

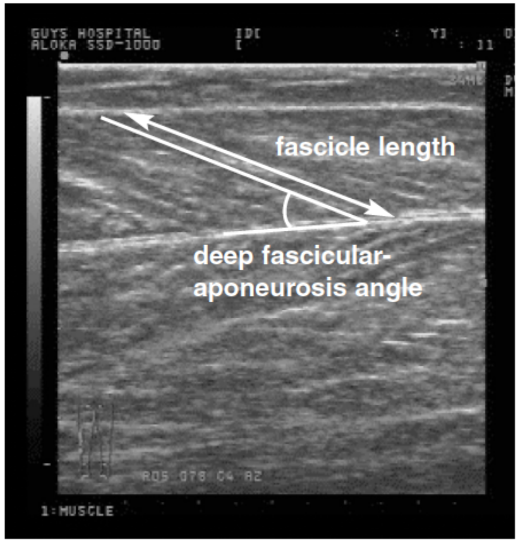
TABLE 1

Summary of Studies—Interventions, Participants, and Results

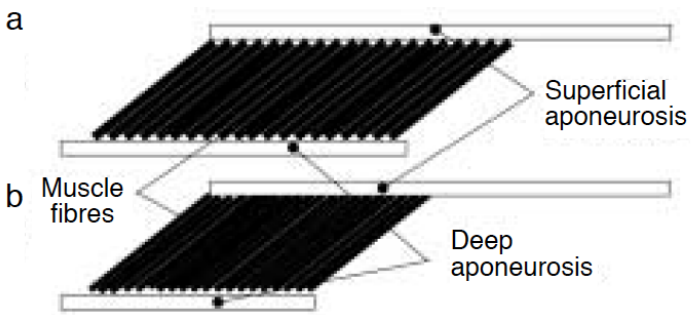
Study	Level of Evidence* and Study Design	Participants	Intervention	Outcome Measures	Results
McPherson et al[24]	Single subject design†	Four children with cerebral palsy (10–18 yr)	Passive stretching and therapeutic positioning Year 1: 60 sec knee extension stretch, 5 repetitions, 3×/d, 5 d/wk Year 2: prone or supine standing devices for 1 hr/d	Hip extension ROM (goniometer) for the study Muscle tone with a device specifically designed	Knee extension increased an average of 4 to 9° during the treatment periods and decreased an average of 5 to 10° during the nontreatment periods SS not tested Decrease in muscle tone during second year of study
Miedaner et al[25]	Single subject, randomized cross-over design	13 persons with cerebral palsy (6–20 yr) severe cognitive and physical impairments	Passive stretching 20–60 sec stretch, five repetitions, 5 d/wk and 2 d/wk	Passive hip, knee, ankle, and forefoot ROM (goniometer)	NS for six of the seven ROM measurements right popliteal angle increased following the higher frequency intervention ($p < 0.05$)
Tremblay et al[19]	Level II Small RCT	21 children with spastic cerebral palsy (3–14 yr)	Passive stretch One occasion for 30 min on tilt table for ankle dorsiflexion stretch	Quality of passive ankle movement (Kin Com dynamometer and surface electrodes) Quality of triceps surae contraction (Kin Com dynamometer and surface electrodes)	Decreased resistance to passive movements up to 35 min after stretch ($p < 0.05$) Decreased EMG response during passive movements up to 35 min after stretch ($p < 0.05$)
Richards et al[20]	Level II Small RCT	19 children with spastic hemiplegia or diplegia (3–13 yr)	Passive stretch One occasion on tilt table 30 sec for ankle dorsiflexion stretch	Muscle activation of tibialis anterior (EMG) Gait analysis (video recording) Gait (Spastic Locomotion Disordered Index)	Improved activation of tibialis anterior ($p < 0.01$) NS NS
Fragala et al[23]	Single subject design	7 children and adolescents with cerebral palsy (4–18 y) GMFCS levels IV or V	Passive stretching and therapeutic positioning 40–60 s, 3 repetitions, 1–2×/wk and routine positioning in classrooms (ie, use of wheelchairs, reclined seats, supine lying and side lying. Standing devices were not used)	Knee and hip extension ROM (goniometer)	No consistent changes in ROM across participants
O'Dwyer et al[21]	Level II small RCT	15 individuals with spastic cerebral palsy (6–19 y)	Passive stretching 30 min stretch, 3×/wk for 42 d	Contracture of triceps surae (passive torque of ankle joint)	NS Reduction in spasticity ($p < 0.025$)
Darrah et al[22]	Level IV Cohort study without control group	23 adolescents with cerebral palsy (11–20 y)	Active stretching Stretching program for hamstrings, quadriceps, hip adductors, internal rotators, and ankle plantar flexors (10–15 sec hold) 3×/wk for 10 wk	Spasticity of triceps surae (tonic stretch reflex) Flexibility of hamstring muscles (sit and reach test) Flexibility of hip adductors (intermalleolar distance)	NS

Stretching GCM

J Appl Physiol 111: 435–442, 2011.



Pennation angle : about 25 deg at resting



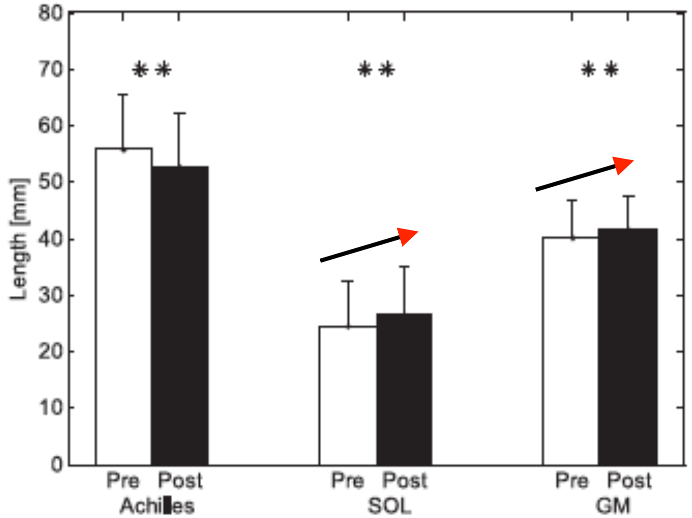


Fig. 6. Comparisons of the Achilles tendon resting length and SOL and GM fascicle lengths measured at full knee extension and 0° ankle dorsiflexion before and after the 6-wk treatment. ** Significant difference with $P < 0.01$.

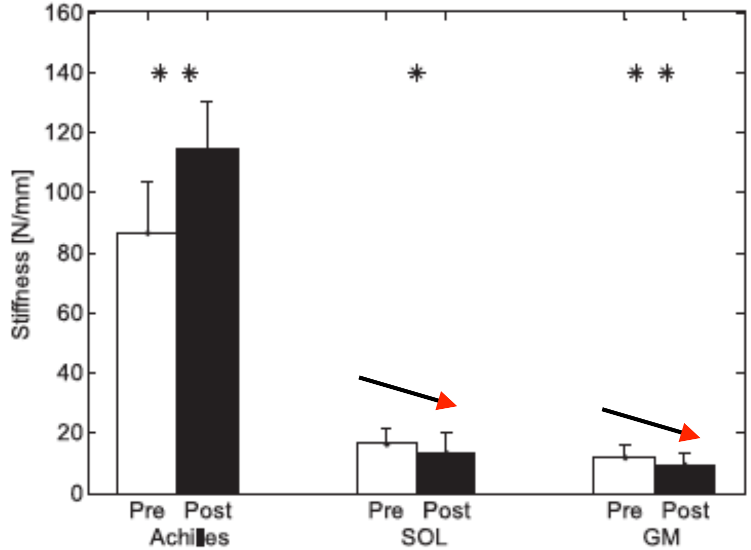


Fig. 7. Comparisons of the Achilles tendon stiffness and SOL and GM fascicular stiffness lengths measured at full knee extension and 0° ankle dorsiflexion before and after the 6-wk treatment. *Significant difference with $P < 0.05$; **significant difference with $P < 0.01$.

J Child Orthop
DOI 10.1007/s11832-015-0664-x

ORIGINAL CLINICAL ARTICLE

Effects of ankle–foot braces on medial gastrocnemius morphometrics and gait in children with cerebral palsy

Matthias Hösl[1,2] · Harald Böhm[1] · Adamantios Arampatzis[2] · Leonhard Döderlein[1]

16 ± 4 weeks after ankle–foot bracing.

less extensibility than controls. Brace wear increased passive dorsiflexion primarily with the knees flexed. During gait, children walked faster and foot lift in swing improved. MG muscle belly and tendon length showed little change, but fascicles further shortened (−11 %) and muscle thickness (−8 %) decreased.

Table 2 Normalised muscle morphometrics of typically developing children (TD) and children with spastic cerebral palsy (CP), as well as changes after bracing (post–pre) in CP

	Degree of MTU stretch	TD	CP		CP post bracing		
		Mean (SD)	Mean (SD)	ES	Mean Δ	95 % CI	ES
MTU length [% shank]	Min	106.1 (1.2)	104.9 (2.1)*	0.7	−0.2	[−1.6, 1.2]	0.1
	Matched mid	109.4 (0.0)	109.4 (2.3)	–	–	–	–
	Max	117.8 (1.8)	114.0 (3.1)**	1.6	0.2	[−1.7, 2.0]	0.2
Muscle belly length [% shank]	Min	63.8 (5.2)	58.4 (5.8)**	1.0	0.7	[−0.7, 2.0]	0.3
	Matched mid	65.2 (5.5)	60.4 (5.5)*	0.9	0.5	[−0.7, 1.7]	0.2
	Max	69.1 (5.4)	63.0 (4.9)**	1.2	0.1	[−1.4, −1.4]	0.0
Muscle belly thickness [% shank]	Min	4.4 (0.5)	3.9 (0.8)*	0.8	−0.3	[−0.6, 0.0]	0.5
	Max	4.2 (0.5)	3.7 (0.8)	0.7	−0.3†	[−0.6, −0.1]	0.6
Fascicle length [% shank]	Min	10.8 (1.6)	9.4 (2.1)*	0.7	−1.0†	[−2.0, −0.1]	0.6
	Matched mid	11.3 (1.6)	9.8 (2.3)*	0.7	−1.1†	[−2.2, −0.1]	0.6
	Max	12.9 (1.9)	10.7 (2.7)**	0.8	−1.5†	[−2.5, −0.2]	0.6
Fascicle angle [°]	Min	24.3 (4.1)	25.0 (4.9)	0.2	1.0	[−1.5, 3.6]	0.2
	Max	19.2 (3.2)	21.4 (5.7)	0.5	0.7	[−2.0, 3.3]	0.1
Tendon length [% shank]	Min	42.4 (5.7)	46.4 (5.0)*	0.7	−0.9	[−2.5, 0.8]	0.3
	Matched mid	44.2 (5.5)	49.0 (5.2)*	0.9	−0.5	[−1.7, 0.7]	0.2
	Max	49.0 (5.4)	51.3 (5.1)	0.4	0.1	[−1.8, 1.9]	0.0

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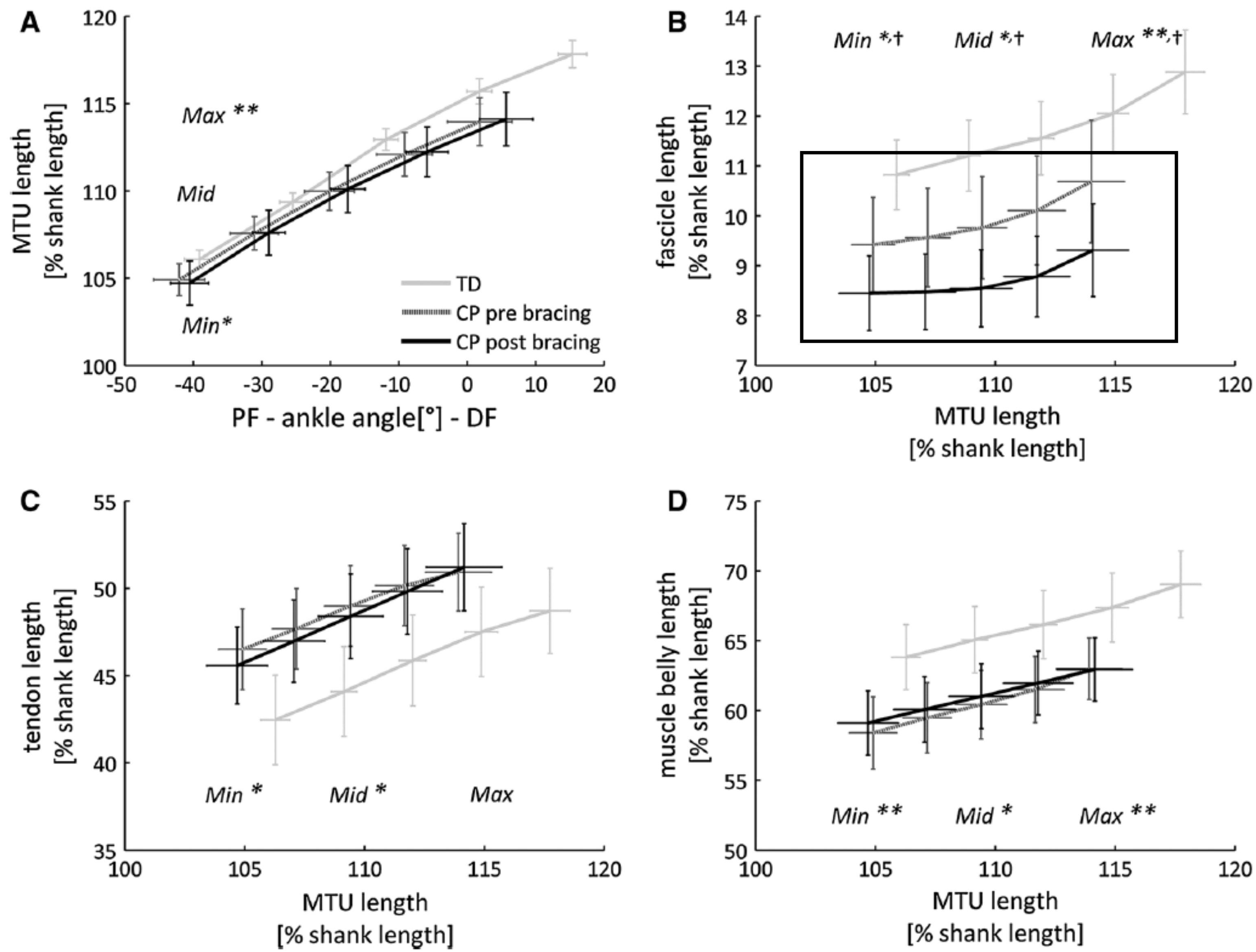

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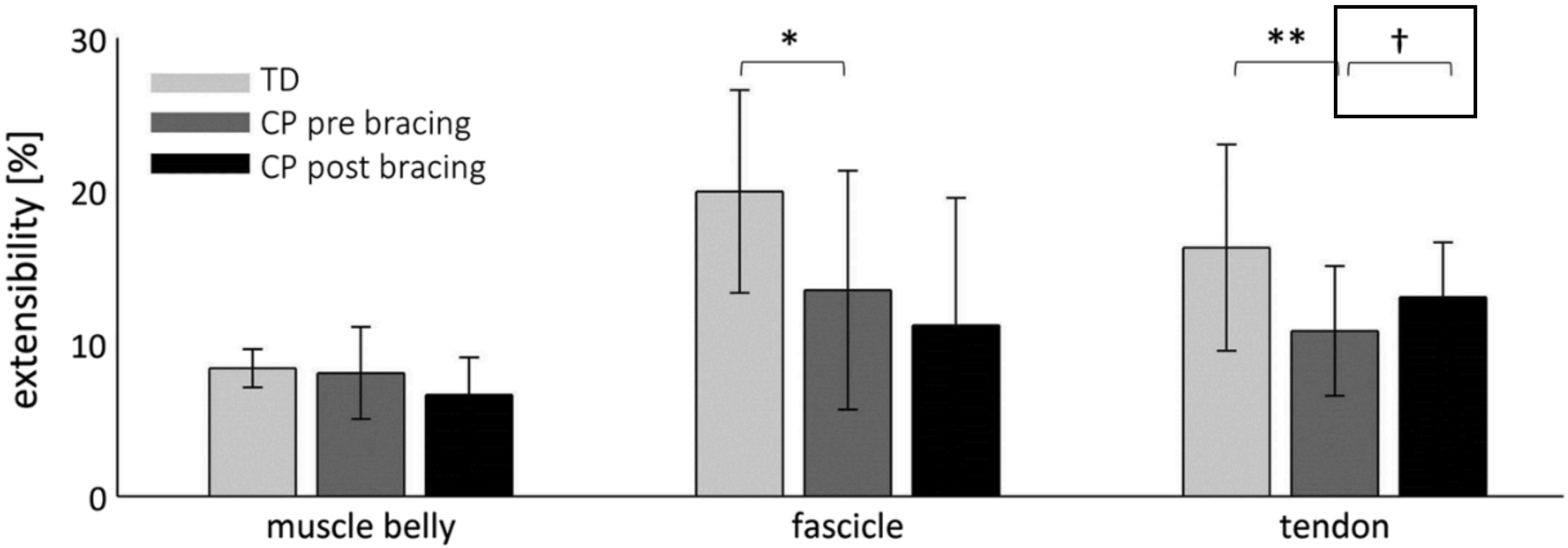

Correction of foot deformities

Progression of foot deformity in spastic CP

Equinus

Equinovarus

Equinovalgus

Planovalgus

Impact of Ankle-Foot Orthoses on Static Foot Alignment in Children with Cerebral Palsy

J Bone Joint Surg Am. 2007;89:806-13

TABLE II Mean Absolute Difference

Measurement	Absolute Value Change (Orthotic Value – Barefoot Value)*	P Value
Hindfoot		
Calcaneal pitch *(deg)*	2.34 ± 1.98	$p < 0.0001$
Talocalcaneal angle *(deg)*	3.61 ± 2.91	$p < 0.0001$
Midfoot		
Naviculocuboid overlap *(%)*	9.39 ± 2.91	$p < 0.0001$
Talonavicular coverage angle *(deg)*	5.45 ± 5.09	$p < 0.0001$
Forefoot		
Lateral talus-first metatarsal angle *(deg)*	4.91 ± 4.25	$p < 0.0001$
Anteroposterior talus-first metatarsal angle *(deg)*	5.32 ± 4.67	$p < 0.0001$

*The values are given as the mean plus or minus one standard deviation.

102 patients (160 feet), 5.1~18.7 years ambulatory

Impact of Ankle-Foot Orthoses on Static Foot Alignment in Children with Cerebral Palsy

J Bone Joint Surg Am. 2007;89:806-13

TABLE III Segmental Alignment of the Foot on Radiographs: Categorical Data for Barefoot and Orthotic Conditions

Deformity	Number of Feet with Deformity in Barefoot Condition*	Number of Feet with Correction to Normal in Orthosis†
Hindfoot		
Calcaneus	5 (3.1%)	1 (20.0%)
Equinus	85 (53.1%)	12 (14.1%)
Valgus	16 (10.0%)	7 (43.8%)
Varus	70 (43.8%)	4 (5.7%)
Midfoot		
Pronation	59 (36.9%)	14 (23.7%)
Supination	50 (31.3%)	9 (18.0%)
Abduction	58 (36.3%)	15 (25.9%)
Adduction	35 (21.9%)	5 (14.3%)
Forefoot		
Planus	70 (43.8%)	25 (35.7%)
Cavus	27 (16.9%)	5 (18.5%)
Abduction	40 (25.0%)	10 (25.0%)
Adduction	48 (30.0%)	4 (8.3%)

*The percentages are based on the total number of feet in the study (160). †The percentages are based on the number of feet with each deformity as shown in the previous column.

102 patients (160 feet), 5.1~18.7 years ambulatory

Long-Term Effects of Orthoses Use on the Changes of Foot and Ankle Joint Motions of Children With Spastic Cerebral Palsy

Xue-Cheng Liu, MD, PhD, David Embrey, PhD, PT, Channing Tassone, MD, Kim Zvara, MD, Brenna Brandsma, DPT, Roger Lyon, MD, Karin Goodfriend, MD, Sergey Tarima, PhD, John Thometz, MD

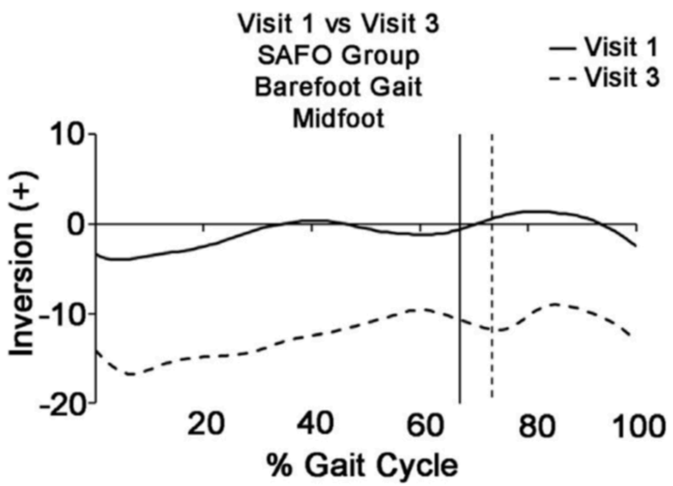

Figure 1. Significant differences in mid-foot segment motion in the coronal plane for the SAFO barefoot gait between first and final visits. SAFO = solid ankle foot orthosis.

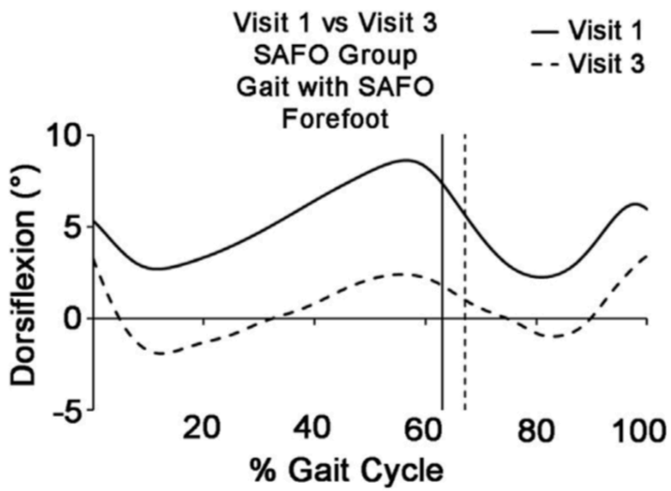

Figure 2. Significant differences in mid-foot segment motion in the sagittal plane for the SAFO between first and final visits. SAFO = solid ankle foot orthosis.

PM R 2017, ePub

“Thank you for listening.”

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