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INSTRUCTIONAL COURSE IC18
Friday, October 23rd 4:00 pm – 6.00pm

FROM STABLE STANDING TO ROCK AND ROLL WALKING A SEGMENTAL KINEMATIC APPROACH TO GAIT REHABILITATION

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Owen E (due publication 2015) Chapter 23. A Segmental Approach to Rehabilitation. In: Rahlin M. (Ed) Physical Therapy for Children with Cerebral Palsy. An Evidence Based approach. SLACK Inc

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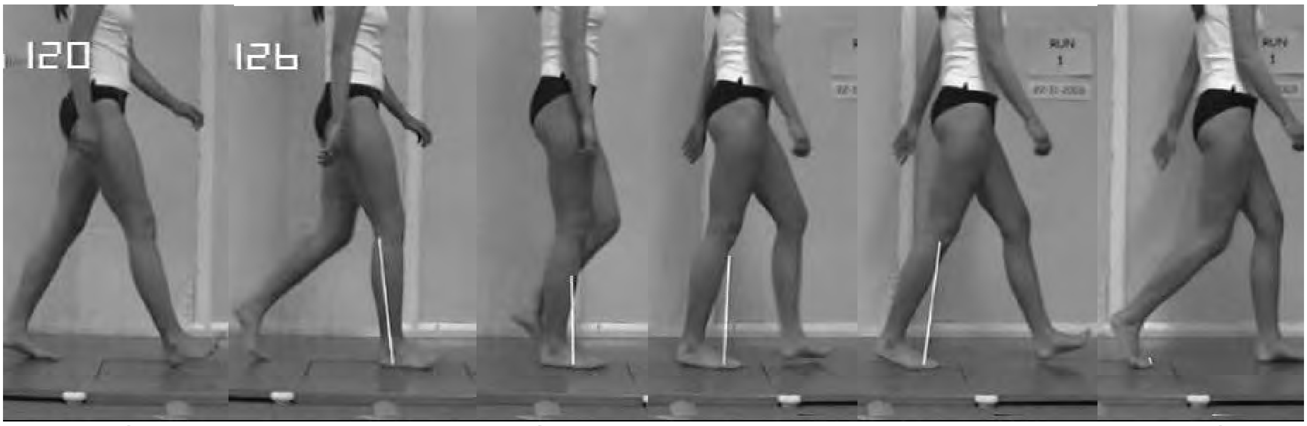
FULL GAIT CYCLE - SIGNIFICANT PERCENTS & TEMPORAL EVENTS



IC FF TMST MKE MHE TO

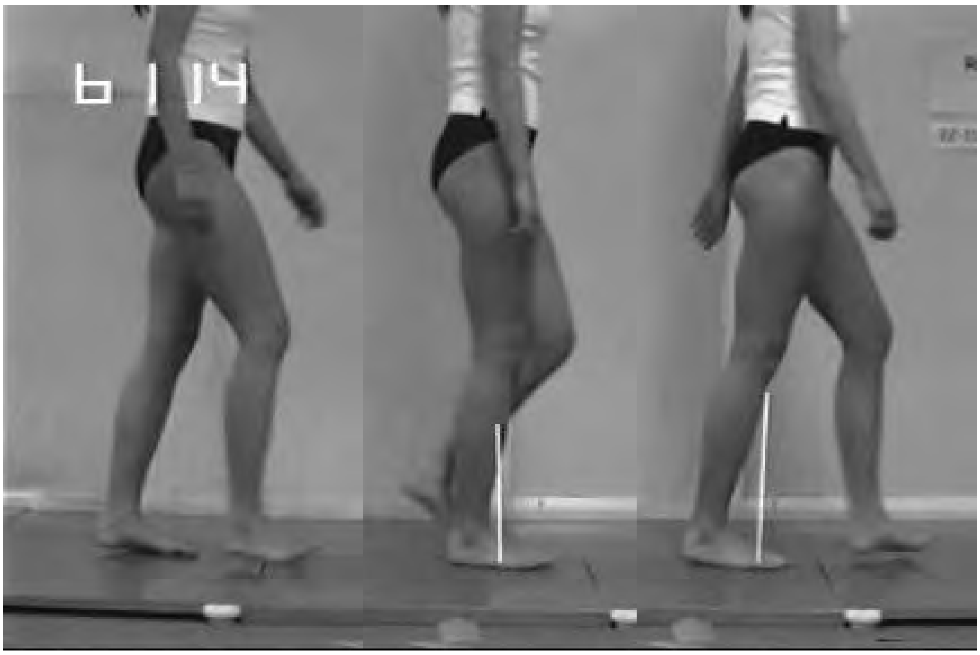
0% 10% 30% 40% 50% 60%

ENTRANCE TEMPORAL MIDSTANCE EXIT

STEPPING – ABBREVIATED GAIT CYCLE

Walking can be divided into ‘walking with full gait cycles and ‘stepping’ (Owen 2014). This is helpful because when children develop walking skills they first stand, then sway in standing, then start stepping and finally they develop full gait cycles. This developmental sequence is, therefore, useful for rehabilitation. Also, walking with full gait cycles may never be a possibility for some patients so stepping is a safe and sustainable alternative walking style.

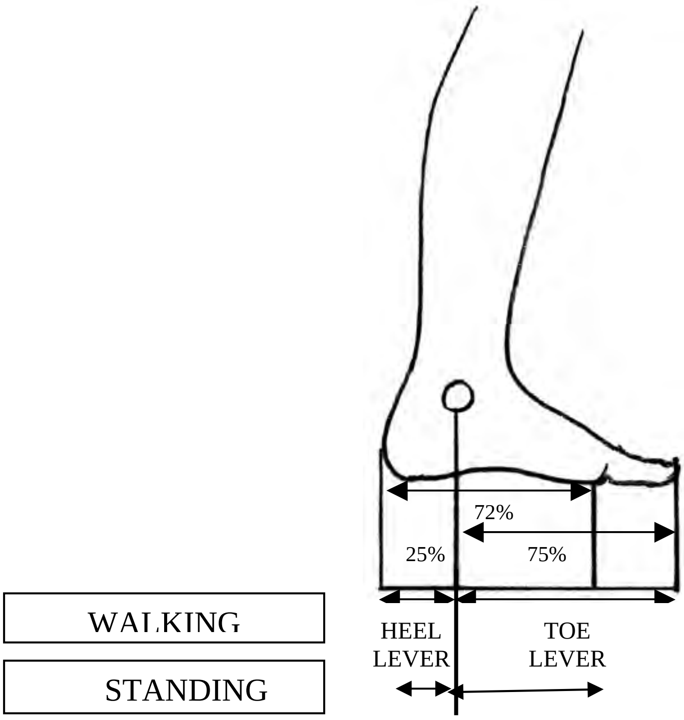
Stepping is defined as walking with an abbreviated gait cycle, single stance finishing at 40% of the normal full gait cycle and swing phase ending at 90%. It is different from strolling, or walking slowly with a full gait cycle and a heel strike. In stepping, initial contact is with a horizontal foot, not the heel, and the shank is vertical not reclined. By the end of single stance the shank and thigh are inclined, there is maximum stance phase knee extension and knee extending moments combined with almost maximum stance phase hip extension and hip extending moments. The stance phase of stepping, as defined, would have some heel rise but in rehabilitation it may be helpful in some circumstances to achieve stepping with the stance foot in full contact until contralateral initial contact.



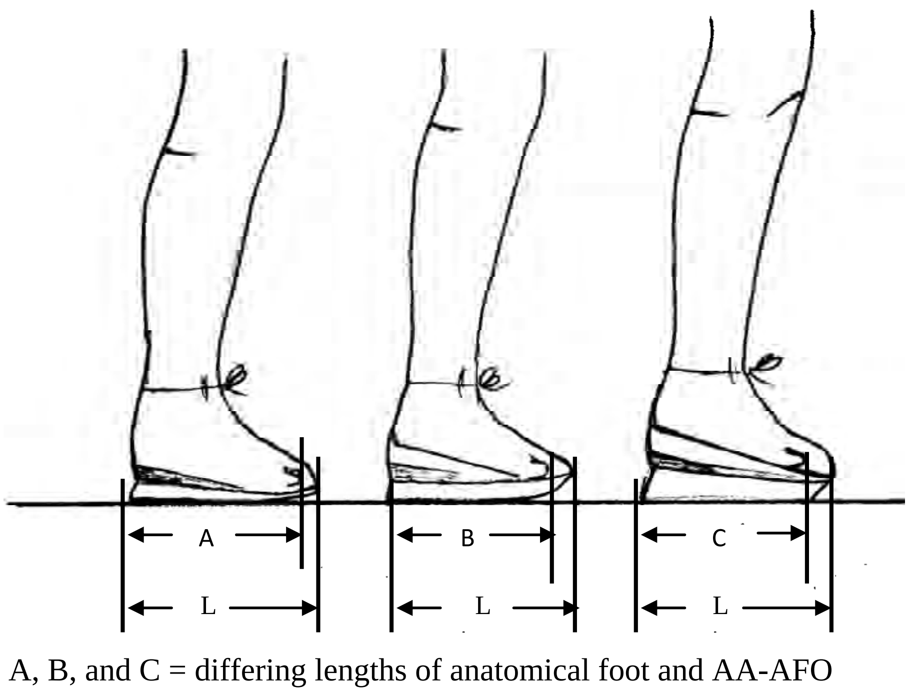
90% 30% 40%

SEGMENT PROPORTION
FOOT, HEEL AND TOE LEVERS, BASE OF SUPPORT

Owen 2014, 2015



When standing and walking the feet act as the ‘base of support’. In the sagittal plane the foot has what are considered to be a ‘heel lever’ and a ‘toe lever’. The length of the heel and toe levers dictates the sagittal length of the base of support. The length of the heel and toe levers of the normal foot have evolved such that the foot can provide a stable ‘base of support’ in standing while also providing sufficient stability and mobility during walking, running and other activities. The levers are set anthropometrically to be at optimum distances from the ankle joint to ensure optimal placement of the ‘point of application’ of the ‘ground reaction force’ at the foot, and optimal alignment of GRF to knee and hip joints during standing and walking.



A, B, and C = differing lengths of anatomical foot and AA-AFO
L = length of footwear required for anatomical height and leg length

ACTUAL AND RELATIVE LENGTHS OF LOWER LIMB SEGMENTS BY AGE

Age	**Height mm**	**Thigh mm**	**Shank mm**	**Foot mm**	**Equivalent Shoe size** with no additions for growth etc	**Whole leg mm**	**Sh/Th %**	**F/Th %**	**F/Sh %**	**F/Leg %**
18-18.5 yrs	1718	417	406	252	38	823	97%	60%	62%	31%
17	1683	406	394	247	37	806	97%	61%	61%	31%
16	1685	409	404	249	38	813	99%	61%	62%	31%
15	1636	396	394	246	37	790	99%	62%	62%	32%
14	1594	388	384	244	37	772	99%	63%	64%	32%
12	1490	363	364	232	35	727	100%	64%	64%	32%
11	1431	346	345	223	34	691	100%	65%	65%	32%
10	1380	328	327	216	33	655	100%	66%	66%	33%
9	1331	310	310	206	31	620	100%	67%	67%	33%
8	1267	292	292	197	30	584	100%	68%	68%	34%
7	1217	278	274	188	28	552	99%	68%	69%	34%
6	1153	257	257	176	27	514	100%	69%	69%	34%
5	1092	239	236	170	26	475	99%	71%	72%	36%
4	1019	218	216	160	24	434	99%	73%	74%	37%
2.5-3yrs	942	195	193	147	22	388	99%	75%	76%	38%
20-23m	825			125	19					
16-19m	790			120	18					
12-15m	737			116	18					
9-11m	730			107						
6-8m	687			99						
3-5m	633			90						
2m	555			81						

SEGMENT PROPORTION TABLE

DEFINITIONS OF SEGMENT LENGTHS:
FOOT: Posterior of heel to end of toes
SHANK: Knee joint to ankle joint
THIGH : Hip Joint to knee joint

References:
Thigh, shank and foot measures are from Tilley AR (2002) “The measure of man and woman. Revised edition” John Wiley & Sons. New York.
Shoe sizes and relative percentages are derived from raw data, from same source, by Elaine Owen.
Elaine Owen Course Manual & Table 21.1 in Owen E. (due publication 2015) Chapter 21. Normal Gait Kinematics and Kinetics In: Rahlin M. (Ed) Physical Therapy for Children with Cerebral Palsy. An Evidence Based Approach. SLACK Inc.

ALIGNMENT OF SEGMENTS AND JOINTS

DEFINITIONS

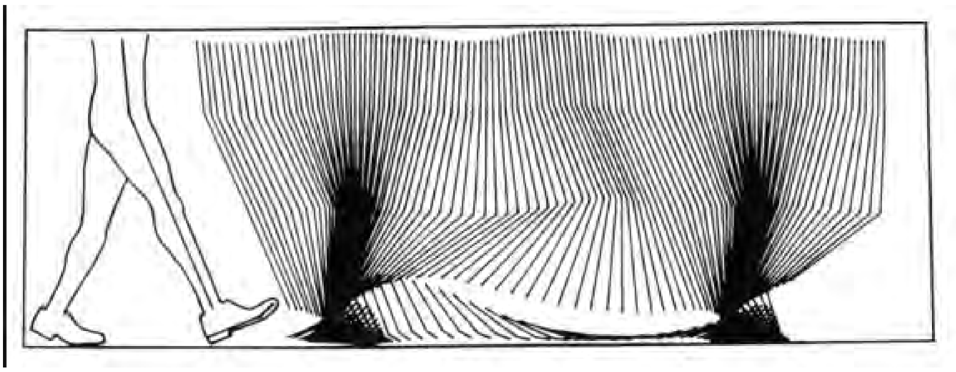
ALIGNMENT OF A JOINT
The spatial relationship between the skeletal segments which comprise the joint (ISO 8551: 2003)

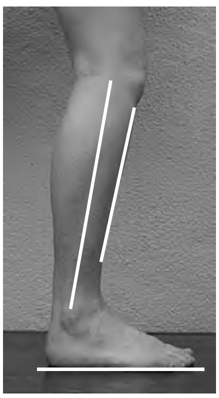
ALIGNMENT OF A SKELETAL SEGMENT
The spatial relationship between the ends of a segment (ISO 8551:2003)

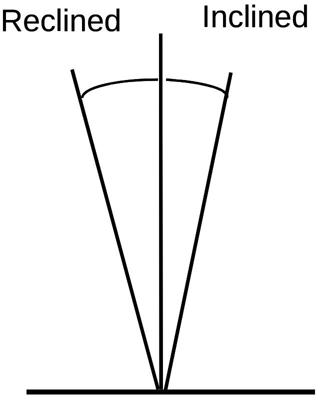
SEGMENT TO VERTICAL ANGLE
SHANK TO VERTICAL ANGLE, THIGH TO VERTICAL ANGLE, TRUNK
The angle of the segment relative to the vertical, measured in the sagittal plane. The angle is described as inclined if the segment is leaning forward from the vertical and reclined if leaning backward from the vertical. It is described in degrees from the vertical, vertical being 0 degrees. (Owen 2004, 2010, 2014, 2015)

SEGMENT TO HORIZONTAL ANGLE
PELVIS TO HORIZONTAL ANGLE, FOOT TO HORIZONTAL ANGLE
The angle of the segment relative to the horizontal, measured in the sagittal plane. Described in degrees from the horizontal, horizontal being 0 degrees. (Owen 2010, 2014, 2015)

Winters (1990)
with permission



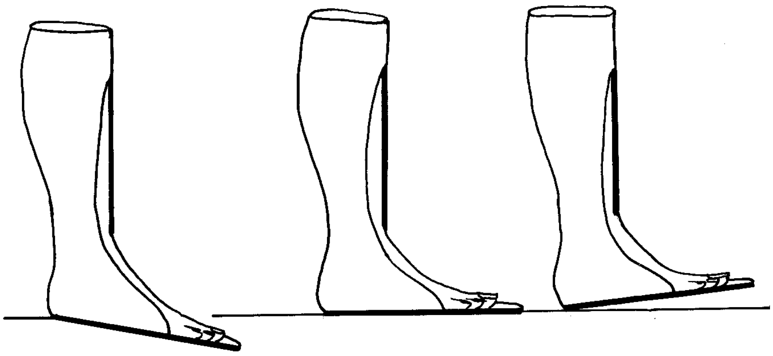




JOINT AND SEGMENT ALIGNMENTS
IN AFO FOOTWEAR COMBINATIONS
Owen 2004,2010,2014,2015

ANGLE OF THE ANKLE IN THE AFO (AAAFO)

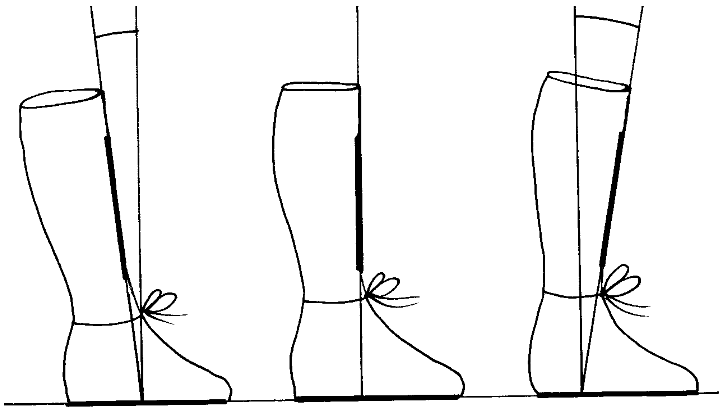
The angle of the line of the shank relative to the base of the lateral border of the foot i.e. a line drawn from the most inferior point of the heel pad on its lateral side to the most inferior point of the foot under the fifth metatarsal head. Described in degrees of plantarflexion or dorsiflexion or plantigrade.



PLANTARFLEXION PLANTIGRADE DORSIFLEXION

SHANK TO VERTICAL ANGLE (SVA)

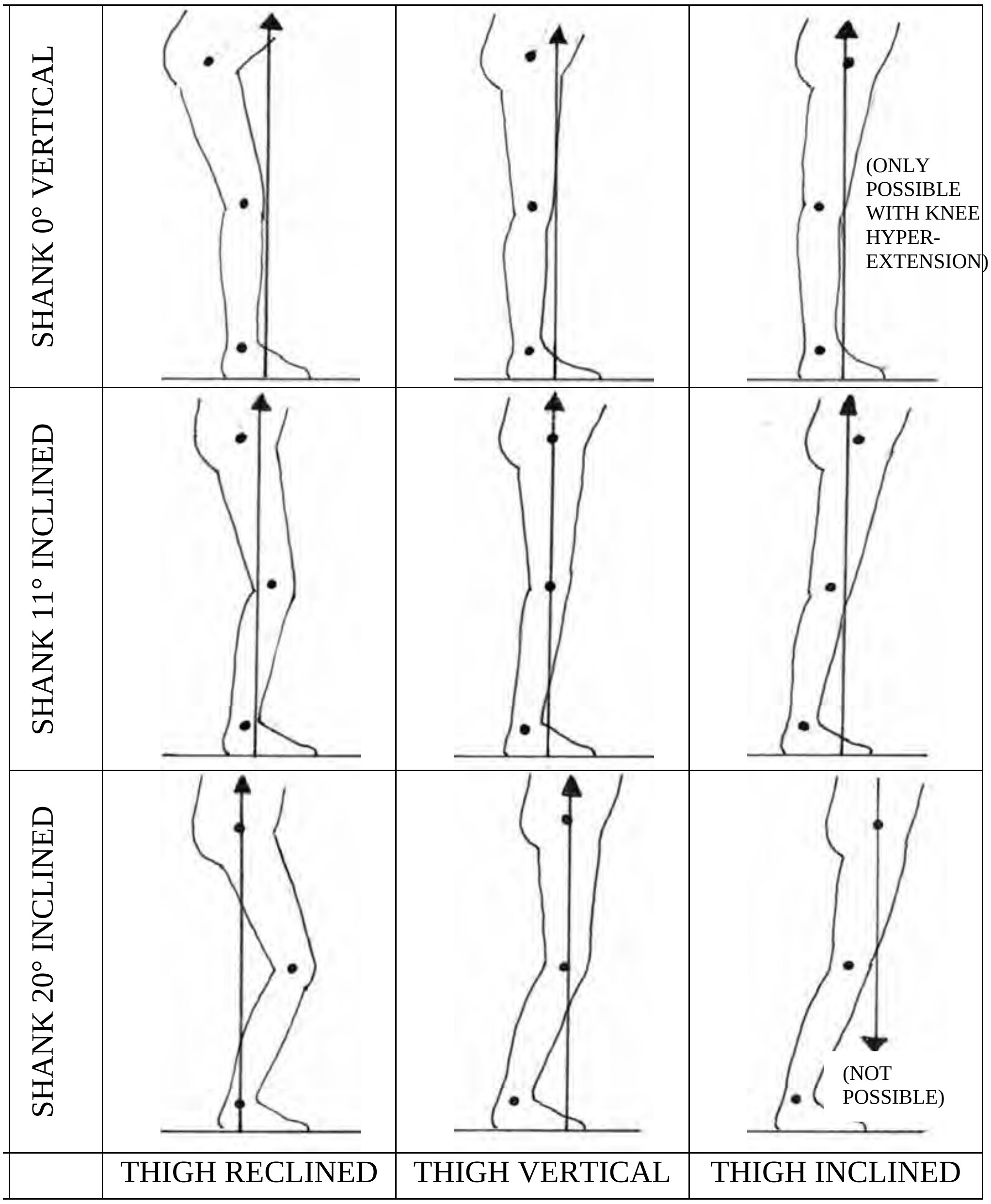
The angle that the line of the shank makes with the perpendicular to the ground, in the sagittal plane, when the patient is wearing the ankle-foot orthosis footwear combination. This is measured in standing with weight equally distributed between heel and sole. It is measured as angles relative to the vertical and named inclined or reclined to define whether there is a forward lean from the vertical or backward lean from the vertical.



RECLINE VERTICAL INCLINE

RELATIONSIP OF SHANK, THIGH, PELVIS AND TRUNK SEGMENTS IN STANDING

Owen E 2004, 2010, 2014, 2015

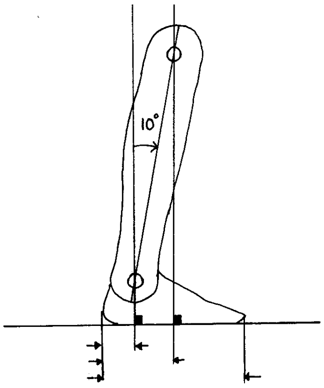


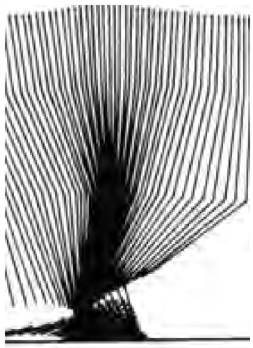
- It is only possible to achieve an inclined thigh with an inclined shank.
- The optimum Shank to Vertical Angle for this is 10-12° incline, the range is probably 7-15° inclined.
- It is not possible to achieve an inclined thigh with a vertical shank/SVA 0° unless the knee hyperextends.
- It is not possible to achieve an inclined thigh with a shank that is inclined 20°/SVA 20° as this requires movement of the centre of mass outside of the base of support.
- It is only possible to achieve both hip and knee extension combined with a vertical trunk when both shank and thigh are inclined.
- The row of images with a Shank to Vertical Angle of 10-12° inclined show that this is the only SVA where it is possible for the thigh to move from reclined to vertical to inclined, translating a vertical trunk over a stable base.
- Shank to Vertical Angle 10-12° inclined places the knee caps over the MTPJs
- Shank to Vertical Angle 20° inclined places the knee caps over the end of toes
- Shank to Vertical Angle 0° vertical places the knee joint centre over the ankle joint.

ALIGNMENT OF FOOT & SHANK AT TEMPORAL MIDSTANCE PRODUCING STABILITY IN STANCE

Shank 10-12° inclined at temporal midstance

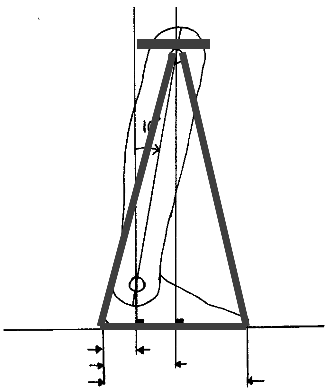
Knee over middle of foot

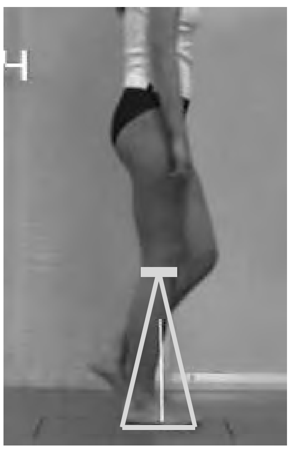




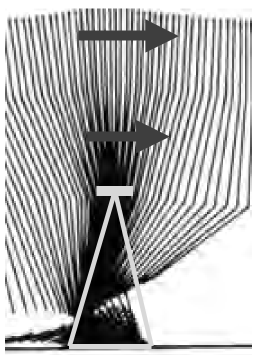
Knee over middle of foot and slowing of shank

'Stability in Stance'





"Trunk Glide"
Perry 1974



Refs: Owen 2004,2010, 2014, 2015

Abstract published as Owen E (2009) Gait and Posture 30S: S49. Also see Owen 2010, 2014, 2015.

HOW SHOULD WE DEFINE THE ROCKERS OF GAIT AND ARE THERE THREE OR FOUR?

Owen E, Child Development Centre, Bangor, UK

SUMMARY

A three-event ankle model of the rockers in gait is inadequate. A four-event model is preferable.

CONCLUSION

Definitions of four rockers are proposed: The mechanisms of the ankle and foot that produce shank kinematic during stance phase of the gait cycle (GC); First rocker during loading response (LR), heel is the pivot, movement at the ankle joint; Second rocker during mid-stance (MST), ankle is the pivot, movement at the ankle joint; Third rocker during terminal stance (TST), forefoot is the pivot, movement at the metatarsal-phalangeal joints; Fourth rocker during pre-swing (PSW), forefoot is the pivot, movement at the metatarsal-phalangeal and ankle joints.

INTRODUCTION

Perry first described the three rockers of gait, ascribing them to three subdivisions of the GC; 'Initial/first rocker' in LR, 'mid-stance rocker' in MST and 'terminal rocker' in TST.[1] She later renamed the rockers, according to the pivot of each rocker; 'heel rocker' during LR, 'ankle rocker' during MST and 'forefoot rocker' during TST and extended the description of the forefoot rocker to include PSW.[2] She attributes the purpose of the rockers to production of tibial advancement during stance, an essential element in forward progression. Perry has renamed the forefoot rocker in PSW as 'toe-rocker'.[3] Perry's three rockers have been reinterpreted as solely relating to ankle kinematic and they have been renamed 'first, second and third ankle rockers', first involving plantarflexion during LR, second involving dorsiflexion, and third involving plantarflexion or movement from dorsiflexion towards plantarflexion, with varying interpretations of the division between second and third rockers.

METHOD AND RESULT

Tabulation of kinematic data by subdivisions of the GC reveals four events and three pivots producing the normal shank kinematic of stance.

	LR	MST	TST	PSW
PROPOSED NAME	1st ROCKER	2nd ROCKER	3rd ROCKER	4th ROCKER
PIVOT	Heel	Ankle	Forefoot / MTPJs	Forefoot / toes
JOINT producing tibial advancement	Ankle	Ankle	MTPJs	MTPJs & Ankle
ANKLE JOINT	Plantigrade to 10° Plantarflex	10° Plantarflex to 10° Dorsiflex	Virtually locked in Dorsiflex 10-12-7°	7° Dorsiflex to 20° Plantarflex
MTPJs	Dorsiflex 25° to 0°	0° to 0°	0° to Dorsiflex 25°	Dorsiflex 25°-55°
SHANK KINEMATIC degrees relative to vertical	25° to 10° Recline	10° Recline to 10° Incline	10° to 25° Incline	25° to 50° Incline
FOOT KINEMATIC	25° Incline to Horizontal	Horizontal	Horizontal to 20° Recline	20° Recline to 60° Recline

DISCUSSION

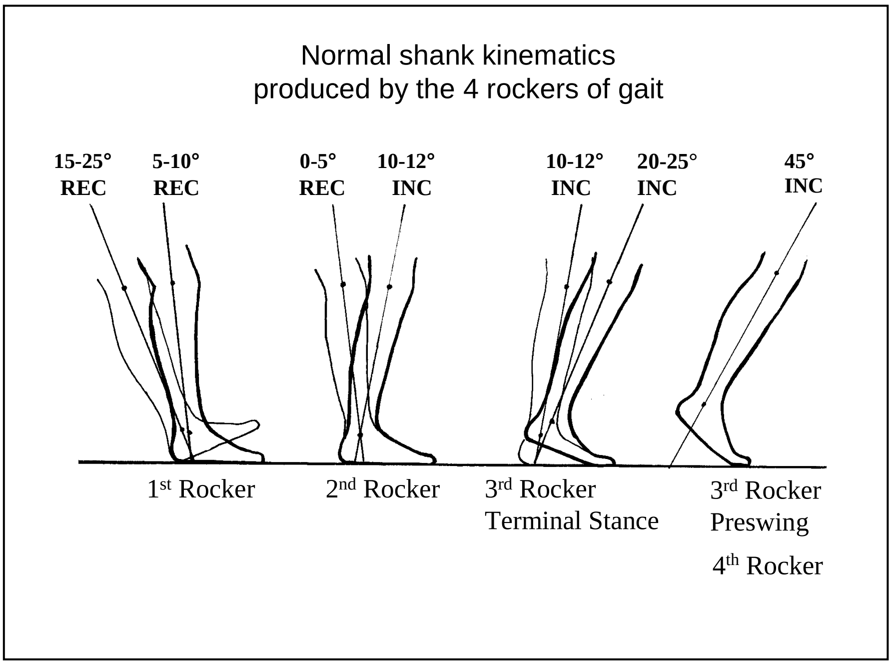
Confining interpretation of the rockers to ankle kinematic does not recognise: 1) The original purpose of describing the rockers; to describe the pivot mechanisms by which normal shank kinematic is produced during stance. 2) The original differentiation between second and third rocker; heel rise, at 30% GC, at the start of TST, the pivot transferring from the ankle to the forefoot. More recent descriptions differentiate these rockers by the point at which the ankle starts to move towards plantarflexion, or the end of TST, neither of which coincide with the start of heel rise. 3) Four events of ankle kinematic in stance, rather than three. A four event model recognises that the ankle is not in motion throughout stance. During TST, the ankle is 'virtually locked', in dorsiflexion.[1, 2] The movement that advances the shank occurs at the metatarsal-phalangeal joints. The stiffness of the ankle in TST is essential for heel rise and the ability to achieve maximum knee extension at 40% GC, maximum hip extension at 50% GC.[1, 2] These omissions may lead to inappropriate or suboptimal interventions.

REFERENCES

1. Perry J (1974) Clin.Orthop Rel Res 102:118-31
2. Perry J (1992) Gait Analysis. McGraw Hill: New York
3. Perry J (2008) In: AAOS Atlas of Orthoses and Assistive Devices. Mosby: Philadelphia

HOW SHOULD WE DEFINE THE ROCKERS OF GAIT AND ARE THERE THREE OR FOUR? ANSWER: FOUR

Owen 2009, 2014, 2015



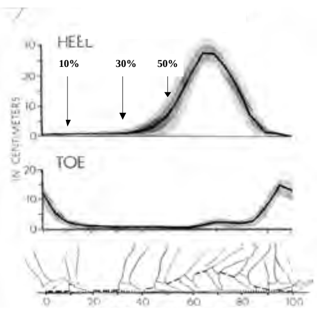
FIRST ROCKER in loading response using ankle movement. Pivot at heel

SECOND ROCKER in midstance using ankle movement. Pivot at ankle

THIRD ROCKER in terminal stance using MTPJ movement.   Pivot at forefoot / MTPJs

FOURTH ROCKER in preswing using ankle and MTPJ movement. Pivot at forefoot /

HEEL AND TOE KINEMATICS



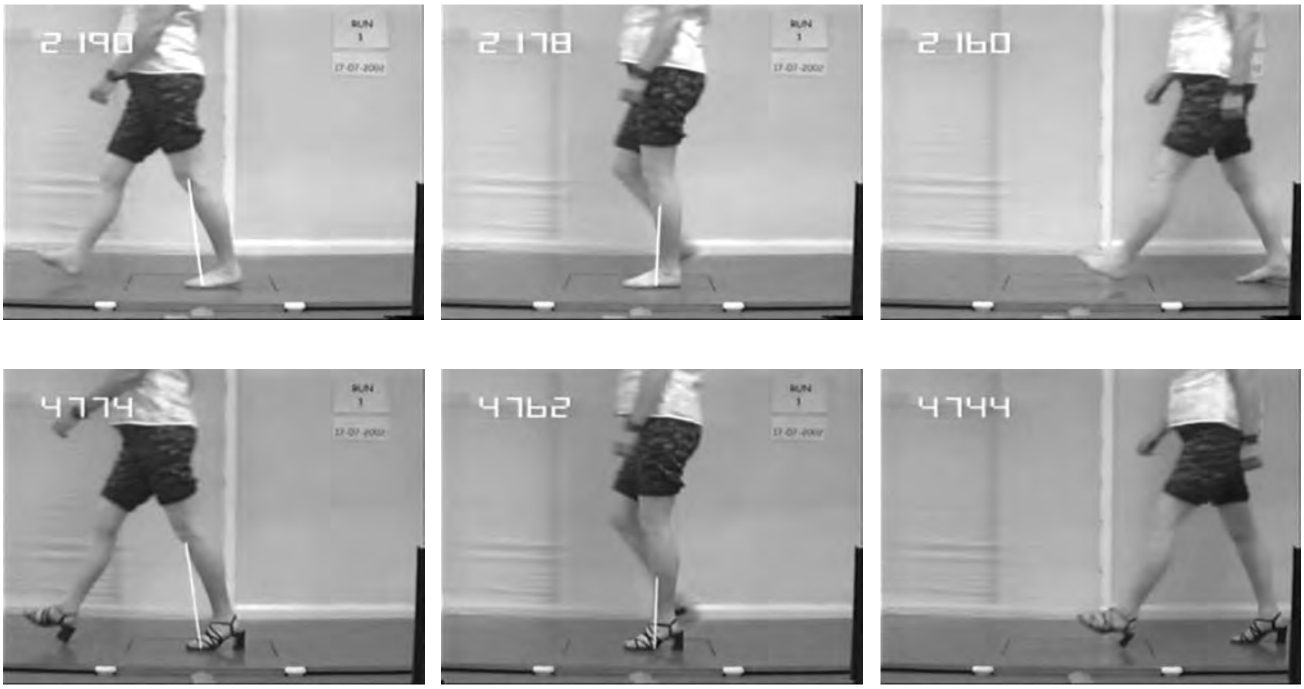
Murray MP (1967)

Refs:

Perry 2008, 2010
Owen 2009, 2014, 2015

ACTUAL AND EFFECTIVE FOOT

Owen 2004, 2010, 2014, 2015, Owen Fatone Hanson (in preparation)



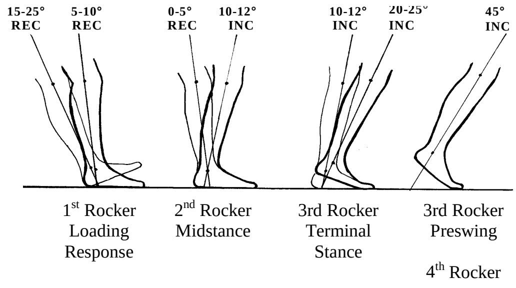
50% GC End of TST | 30% GC TMST | 0% GC IC

When walking in footwear that has a ‘Heel Sole Differential’ or Pitch the base of the footwear becomes the Effective Foot. The kinematics of the Effective Foot mimic the kinematics of the Actual Foot in barefoot gait. The actual foot shifts its kinematics by the degree of pitch in the footwear. The ankle shifts its kinematics by the degree of pitch in the footwear, so as to maintain normal barefoot shank, thigh and trunk kinematics. The ankle joint adjusts to maintain normal segment kinematics.

REPLICATING NORMAL SHANK KINEMATICS IN AFOFCS
ANKLE AND SHANK KINEMATICS ARE INDEPENDENT

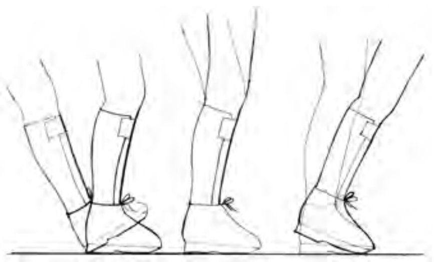
Owen 2004, 2010, 2014, 2015

NORMAL FOOT & SHANK KINEMATICS
PRODUCED BY THE 4 ROCKERS



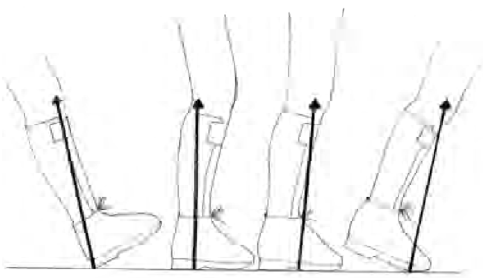
REPLICATING NORMAL
FOOT, SHANK AND THIGH KINEMATICS

Entrance to midstance | Midstance | Exit from midstance



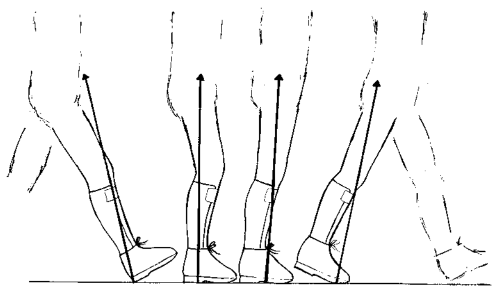
REPLICATING NORMAL
FOOT, SHANK AND THIGH KINEMATICS
AND GRF ALIGNMENT TO KNEE

Entrance to Midstance | Midstance | Exit from Midstance



REPLICATING NORMAL FOOT,
SHANK, THIGH, PELVIS, TRUNK KINEMATICS
AND GRF ALIGNMENT TO KNEE AND HIP

Entrance to midstance | Midstance | Exit from midstance



An importance of the rockers is that the distal segment alignments and kinematics dictate proximal kinematics and kinetics, 'Normal distal produces normal proximal' and 'abnormal distal produces abnormal proximal'. Understanding each of the rockers of gait and incorporating normal segment alignment strategies into all rehabilitation and orthotic interventions for standing, stepping and walking with full gait cycles is essential.

The rockers of barefoot gait are dependent on movement at both the ankle and metatarsal phalangeal joints (MTPJs). If these joints are not able to move it is still possible to produce normal shank kinematics if the correct footwear or orthosis design is used, because joint kinematics and segment kinematics are independent of each other .

When walking in AFOFCs the design of the AFOFC needs to create most normal, foot and shank kinematics, subsequent most normal thigh kinematics and knee and hip kinematics and kinetics. Fr a number of reasons we often have to fix the ankle joint or MTPJs in orthotic designs. This prevents use of anatomical rockers, so normal shank kinematics must be replicated by the use of simulated rockers created by the design of the footwear that is combined with the ankle-foot orthosis.

Normal shank kinematics can be created by determining the optimal SVA alignment of the AFOFC and by optimising the designs of the heels and soles of the footwear to facilitate the foot and shank kinematics required for entry to and exit from temporal midstance. When using AFOFCs the base of the footwear becomes the 'effective foot'. Designs of soles vary the timing and rate of heel rise and shank kinematics. Designs of heels vary the rate of foot kinematics from heel strike to foot flat and shank kinematics.

DEFINITIONS

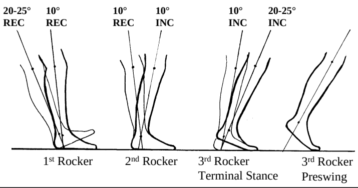
BIOMECHANICAL OPTIMISATION is the process of designing, aligning and tuning and AFOFC to optimise its performance.

TUNING is the process whereby fine adjustments are made to the AFOFC, in order to optimise its performance during a particular activity, for example standing, stepping, walking, stairs, running.

ALGORITHM FOR DESIGNING, ALIGNING & TUNING AFOFCS BASED ON SHANK KINEMATICS. ALGORITHM 1.

Owen 2005, 2010, 2014, 2015

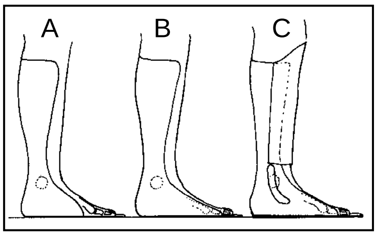
NORMAL SHANK KINEMATIC IN STANCE PHASE?



- YES → SWING PHASE / INITIAL CONTACT PROBLEM?
  - YES → Posterior Leaf Spring or Hinged AFOFC
  - NO → AFO not required unless other indications
- NO → FIXED ANKLE AFOFC with appropriate Angle of Ankle in AFO

ABNORMALITY OF SHANK KINEMATIC = INSUFFICIENT INCLINE IN MST AND/OR TST

→ AFO DESIGN AT ANKLE JOINT
Ankle joint fixed
Plantarflexion and recline resist design, A or B



→ AFO DESIGN AT METATARSAL PHALANGEAL JOINTS
MTPJs free to extend so as to enable inclination of shank through use of anatomical 3rd rocker, A

→ FOOTWEAR DESIGN
Design which permits inclination of shank in TST = Flexible sole and sole profile design which enables MTPJ extension and use of anatomical 3rd rocker

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ABNORMALITY OF SHANK KINEMATIC = EXCESSIVE INCLINE IN MST AND/OR TST

→ AFO DESIGN AT ANKLE JOINT
Ankle joint fixed
Dorsiflexion and incline resist design, B or C, depending on severity of gait abnormality

→ Able to control shank kinematic in TST once ankle fixed sufficiently in AFO?
- YES → AFO DESIGN AT METATARSAL PHALANGEAL JOINTS (MTPJs free to extend…, A)
- NO → AFO DESIGN AT METATARSAL PHALANGEAL JOINTS
MTPJs fixed so as to prevent any inclination of shank through use of anatomical 3rd rocker, B or C

→ FOOTWEAR DESIGN
Design which resists excessive inclination of shank in TST= Stiff sole and sole profile design which provides simulated 3rd rocker

NOTE:

See steps on MTPJ and sole design

TUNING PROCESS
Trials by slow motion kinematic video, with or without kinetics, to optimise kinematic / kinetic gait parameters

↓

TUNE MIDSTANCE by adjusting Heel Sole Differential of the AFOFC to determine the alignment of the AFOFC (SHANK to VERTICAL ANGLE/ SHANK ANGLE to FLOOR), which produces optimal shank kinematic and GRF alignment. A useful starting point is 10-12° incline.

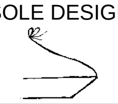
↓

TUNE EXIT FROM MST (TST) by adjusting sole design to optimise shank kinematic and GRF alignment

- Flexible sole with flat or rounded sole profile produces optimal result?
  - YES → SOLE DESIGN

  - NO → Stiff sole with rocker sole profile (optimised position and toe spring angle) produces optimal result?
    - YES → SOLE DESIGN

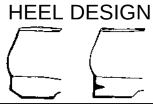
    - NO → Stiff sole with point loading rocker (optimised position and toe spring angle) produces optimal result?
      - YES → SOLE DESIGN



→ **TUNE ENTRY TO MST (IC, LR)** by adjusting heel design to optimise shank kinematic and GRF alignment

- Plain heel produces optimal result?
  - YES → HEEL DESIGN

  - NO → Angular velocity of shank during entry to MST needs to be reduced by use of a negative or cushion heel?
    - YES → HEEL DESIGN



    - NO → Angular velocity of shank during entry to MST needs to be increased by use of a positive heel?
      - YES → HEEL DESIGN

CATEGORIES OF STANCE PHASE ABNORMALITIES OF SHANK KINEMATICS CORRECTION BY ANKLE-FOOT ORTHOSIS FOOTWEAR COMBINATIONS

Owen 2004, 2010, 2014, 2015, 2016

NOTE: Some gaits have a combination of abnormalities within the same gait cycle

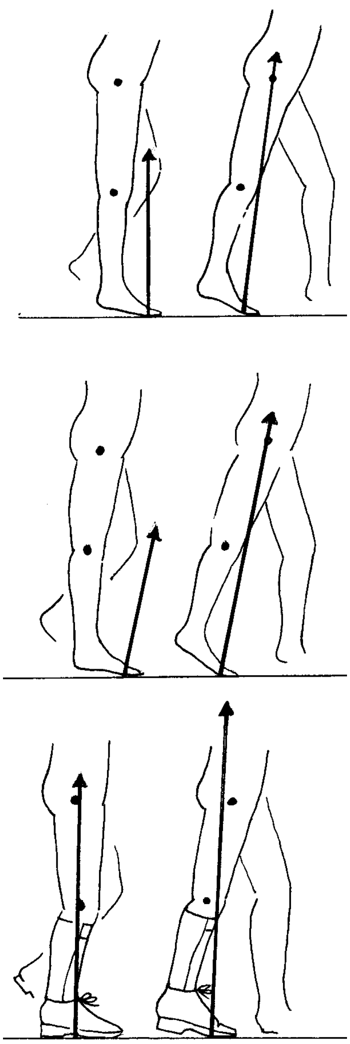
INSUFFICIENT SHANK INCLINE

MST TST

a

b

c



a and b Shank insufficiently inclined in MST. Vector excessively anteriorly aligned at foot, knee and hip in MST. Vector vertical (1a) or forward leaning (1b).

c AFOFC producing normal shank kinematics at MST and TST by increasing the inclination of the shank with resultant improvement of GRF alignment at foot, knee and hip.

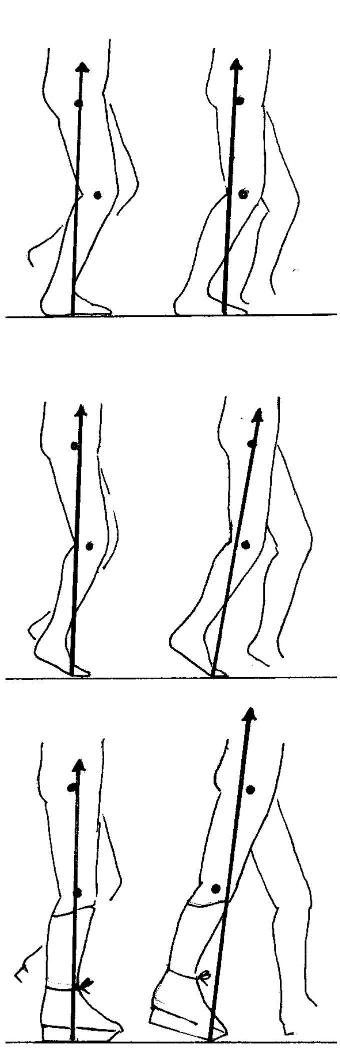
EXCESSIVE SHANK INCLINE

MST TST

d

e

f

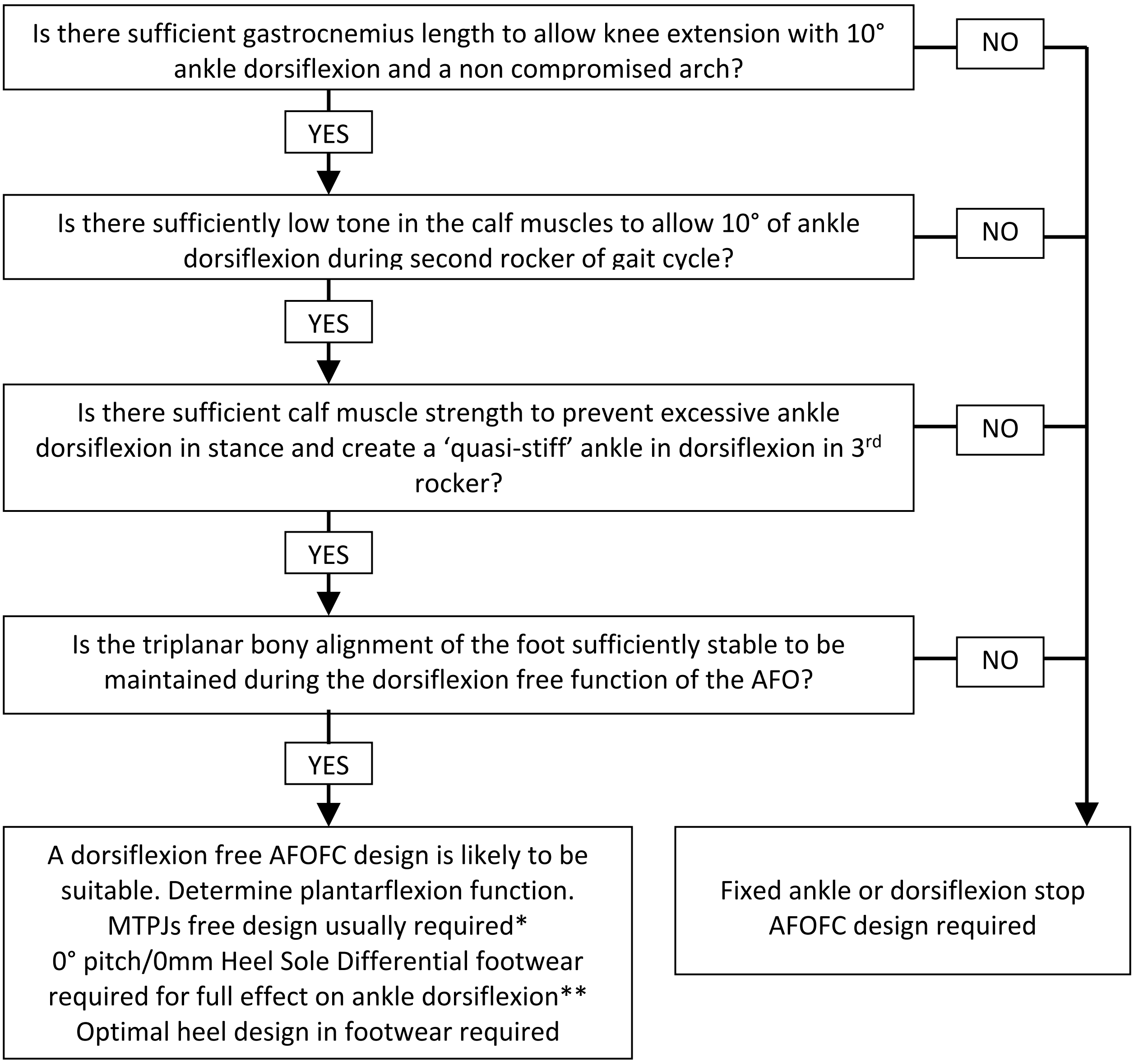


d and e Shank excessively inclined in MST. Vector aligned posterior to knee in MST and TST with variable alignment at hip and foot. Different foot kinematics in (1d) and (1e).

f AFOFC producing normal shank kinematics at MST and TST by reducing shank inclination with resultant improvement of GRF alignment at foot, knee and hip.

ALGORITHM FOR DORSIFLEXION FREE AFOFCS BASED ON CALF MUSCLE LENGTH, STRENGTH, STIFFNESS AND SKELETAL ALIGNMENT. ALGORITHM 2.

Owen 2013, 2014, 2015, 2016.



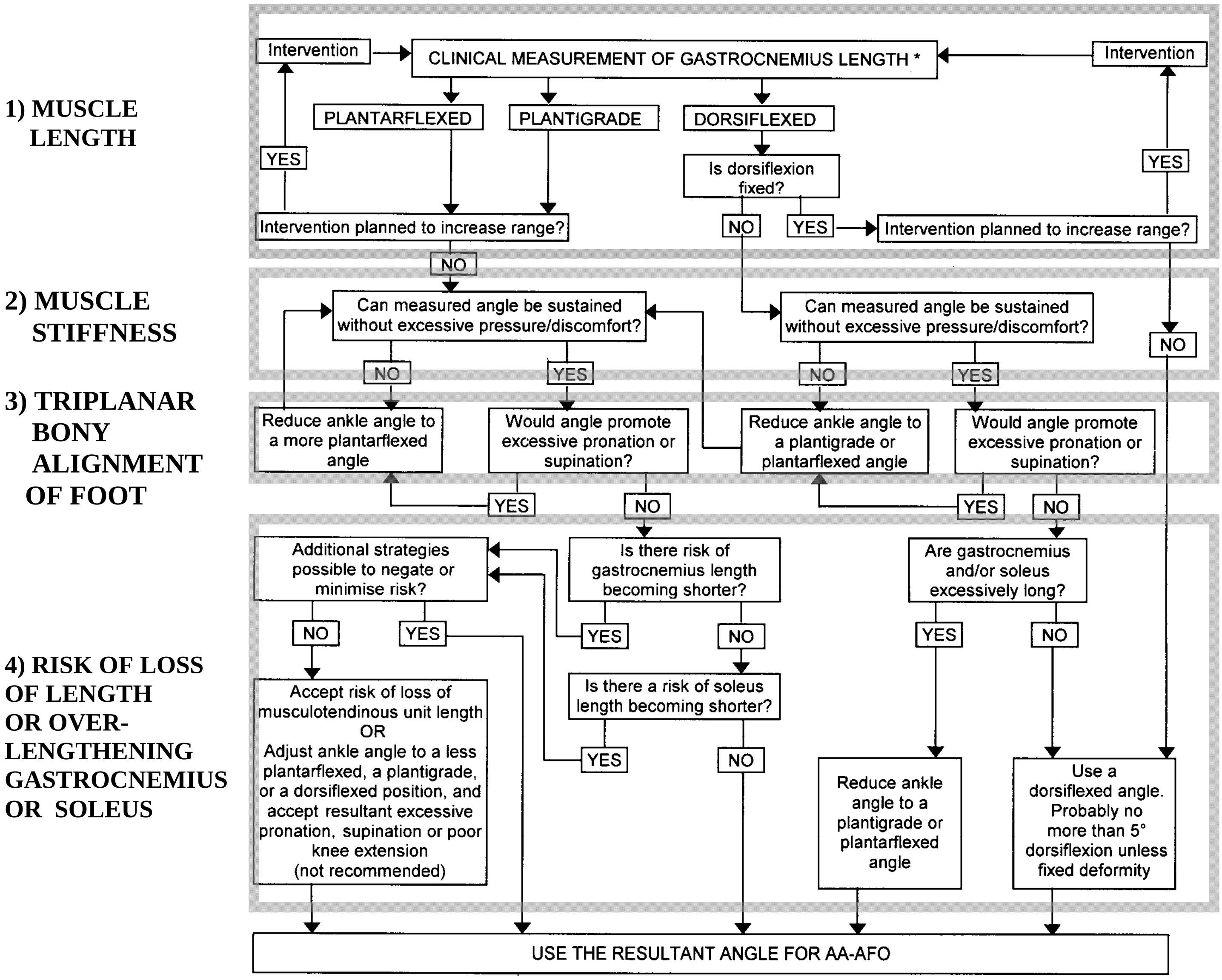
* An AFOFC with MTPJ free design is usually required, to allow MTPJ extension during third rocker, and patients who meet the criteria for a dorsiflexion free AFO usually meet the criteria for an MTPJ free design. If they do not a rocker sole profile is required on the footwear as restriction in MTPJ extension may produce excessive ankle dorsiflexion, a compensatory response required to enable normal shank kinematics if MTPJs are fixed and not compensated for by a rocker sole profile.

** To obtain 10-12° of ankle joint dorsiflexion in gait the dorsiflexion free AFO needs to be combined with footwear that has a 0mm Heel Sole Differential (HSD) or 0 degree pitch. For each degree of pitch in the footwear there will be a reduction of one degree of ankle dorsiflexion. This is because gait requires normal shank kinematics and ankle joint kinematics adjust to the pitch of the footwear to achieve this. In normal gait the shank is 10-12° inclined at the end of mid-stance. A 10-12° pitch in the footwear negates the need for ankle dorsiflexion to achieve this.

ALGORITHM FOR DETERMINING THE OPTIMAL ANGLE OF THE ANKLE IN THE AFO. ALGORITHM 3.

Owen 2005, 2010, 2014, 2015, 2016

DEFINITION: THE ANGLE OF THE LINE OF THE SHANK RELATIVE TO THE BASE OF THE LATERAL BORDER OF THE FOOT

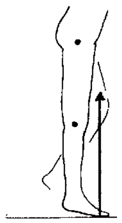


NOTE: THERE ARE INTERVENTION OPPORTUNITIES THROUGHOUT

GUIDELINES FOR OPTIMAL SVA ALIGNMENTS

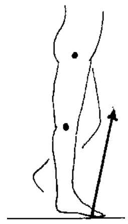
Owen 2002, 2004, 2010, 2014, 2015

SVA ALIGNMENT
GMFCS 1 2 3
Insufficient incline. No shank reversal



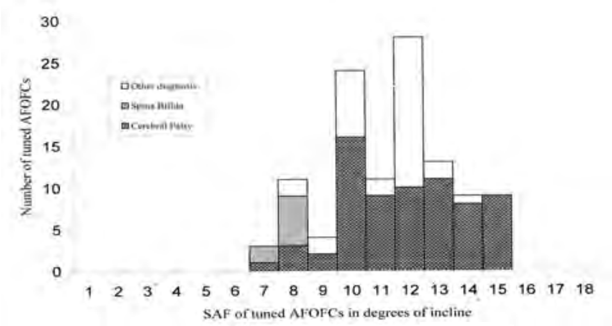
10-12° Incline

SVA ALIGNMENT
GMFCS 1 2 3
Insufficient incline with shank reversal

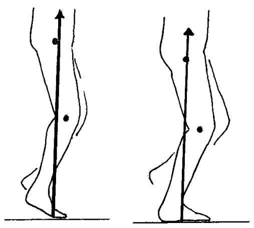


14-15° Incline

Owen 2002
GMFCS 1&2
112 legs
Mean SVA 11.4° Inc

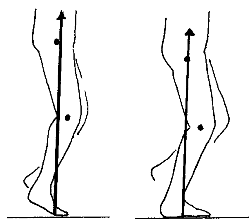


SVA ALIGNMENT
GMFCS 1 2 3
Excessive incline. No knee or hip stiffness



10-12° Incline

SVA ALIGNMENT
GMFCS 1 2 3
Excessive incline with knee or hip stiffness



15-19° Incline

The optimum SVA of an AFOFC seems to be dependent on 2 main factors;

1. The primary neurology
2. The consequent stiffness of the muscles and joints at the hip and knee

HEEL AND TOE LEVERS IN FOOTWEAR DESIGN
STABLE SOLE DESIGNS FOR STANDING, STEPPING & WALKING

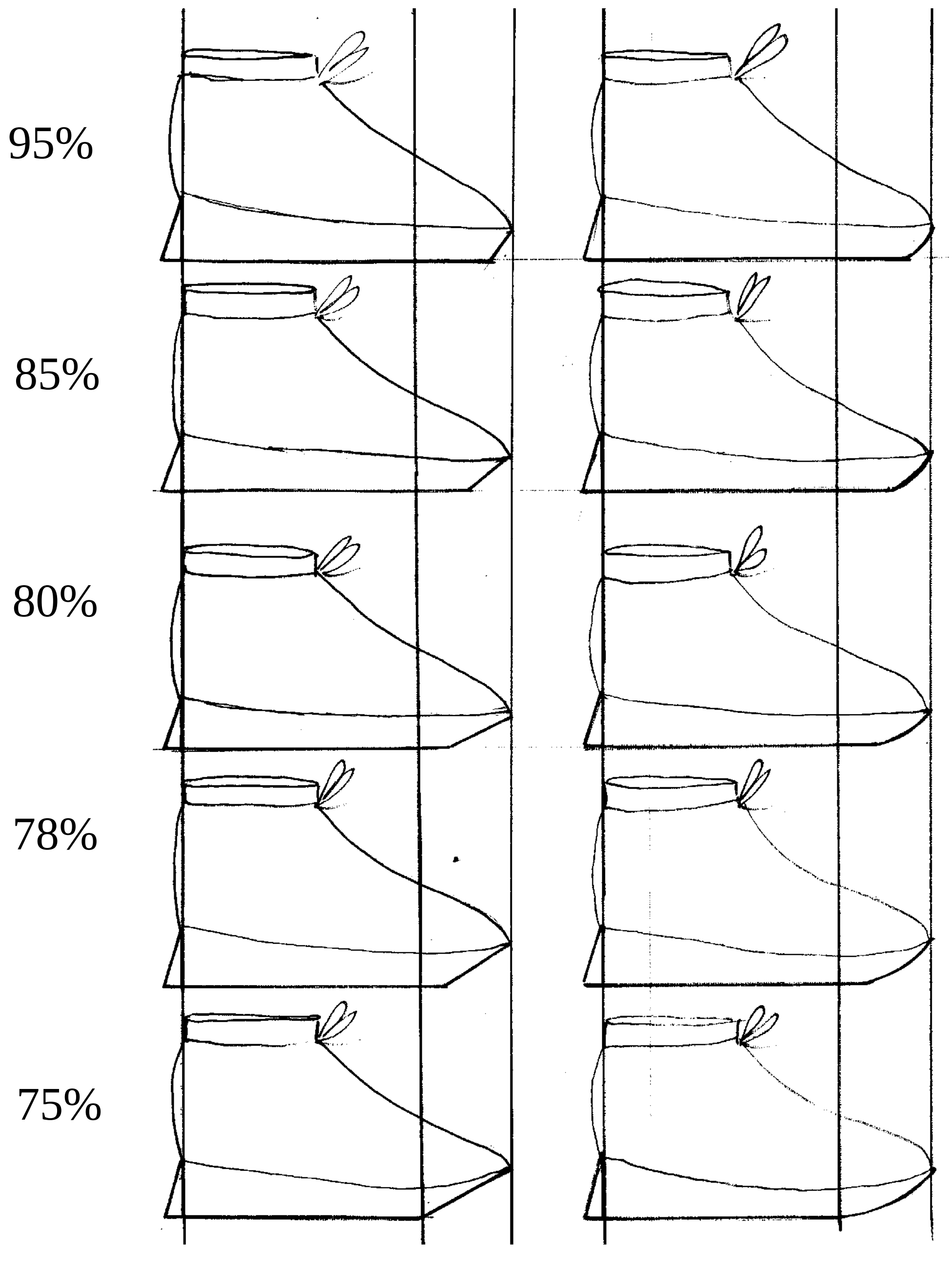
Owen 2004, 2005, 2010, 2014, 2015

Many children will require an MTPJ Free AFO design coupled with flexible footwear. However, some children with gait category ‘ Insufficient shank incline’ and many children with gait category ‘Excessive shank incline’ will need fixed MTPJs coupled with stiff rocker soles. The length of the rocker position determines the ‘toe lever’ which influences the timing of heel rise. The heel of the footwear cannot rise until the GRF reaches the start of the rocker. The more distal the rocker is placed the longer the ‘toe lever’ and the greater the leverage to prevent heel rise. The MTPJs on a normal foot are at 72% of the length of the foot, which provides the necessary stability in standing and mobility in walking. When optimising AFOFCs the rocker positions may need to be more or less than 72% of the length of the footwear. The key to successful optimisation of rocker soles is to have 1) the optimum size of footwear to provide optimum effective foot length 2) a very stiff sole and 3) a flat sole profile to the start of the rocker. Rockers are optimised by trials.

A GUIDELINE FOR ROCKER POSITIONS:

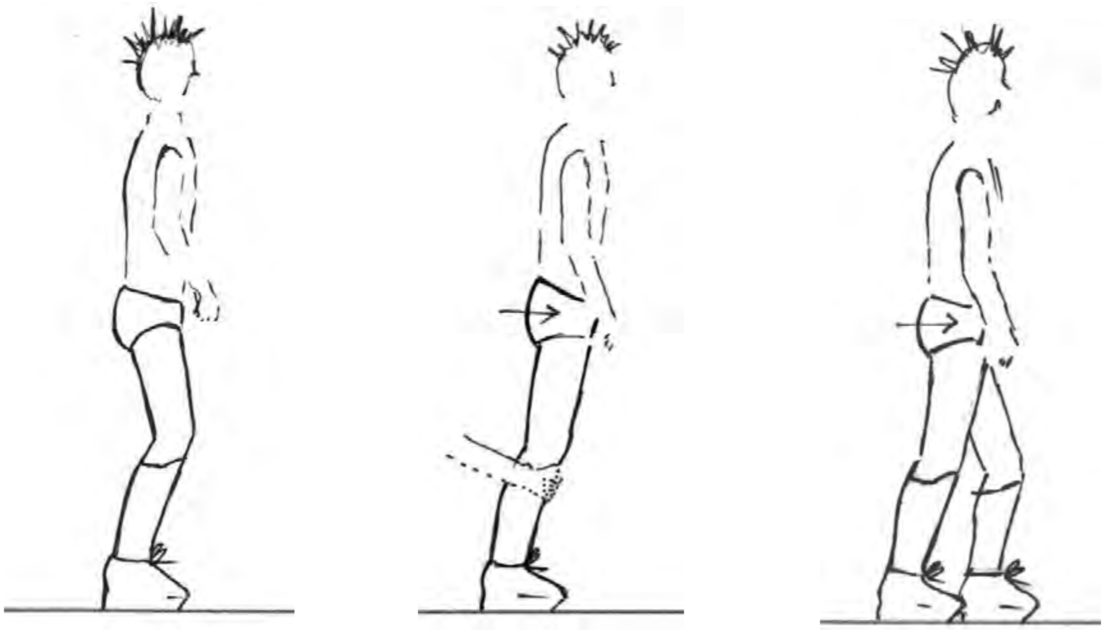
WALKING WITH FULL GAIT CYCLES: Insufficient Shank Incline 75%; Excessive Shank Incline without significant stiffness at hips and knees, 75- 95%, with stiff hips and/or knees 85-95%. STEPPING can tolerate rockers at 90-100%. STANDING can tolerate rockers of 100% or more.

STIFF POINT LOADING ROCKER **STIFF ROUNDED ROCKER**



TEACHING STANDING, FIRST OR SMALL STEPS, STEPPING WITH OR WITHOUT WALKING AIDS

Owen E 2014, 2015



A **B** **C**

Biomechanical optimisation of AFOFCs does not just apply to those who can ambulate with full gait cycles, it also applies to children or adults who are just starting to take their first steps and also to those who have significant problems and are therefore only able to take small steps.

When teaching first steps to children with significant problems of muscle stiffness, muscle weakness, balance or other disabilities, it is a useful to use the following sequence. It can also be applied when teaching walking with small steps or stepping.

A Teach standing in AFOFCs which have optimised inclined SVA, combined with footwear that provides a very stable base. This footwear would have a flat sole profile, with an appropriate rocker at the appropriate place, and may also include a back float. This footwear design will provide a good base of support.

B In standing, encourage them to then translate the trunk anteriorly and posteriorly, moving the thigh from a reclined to vertical and inclined positions. Initially, they may need distal support at the top of the shanks to be able to do this.

C Encourage small steps with the stance leg moving from an MST position to an early TST position, with the thigh inclined and the GRF becoming aligned anterior to the knee and posterior to the hip, providing stability in stance.

D As walking progresses, they can start to develop late TST, TSW and LR, if possible.

E Some children and adults will not develop the ability to achieve a full TST combined with contralateral TSW. However, achieving TST to 40% GC provides a good stable gait.