CEREBRAL PALSY GAIT

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Do You Know?

- **1 in 3 children with CP cannot walk.**
- **There are more boys born with Cerebral Palsy than girls** (for every 100 girls there are 135 boys).
- **About 1/2 of children with CP are born prematurely.**
- **More than 1/2 of children with CP have bilateral spastic Para paresis**.
- **About 1/3 of children with CP have hemiplegic**.
- **Stroke in a baby or child less than the age of 3 results in CP.**

DEFINATION

Cerebral palsy (CP) describes a group of permanent disorders of the development of movement and posture, causing activity limitation, that are attributed to non progressive disturbances that occurred in the developing fetal or infant brain. The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, perception, cognition, communication, and behaviors, by epilepsy, and by secondary musculoskeletal problems.

(The Definition and Classification of Cerebral Palsy, April 2006)

COMPONENTS OF CERBRAL PALSY CLASSIFICATION

(Definition and Classification of CP April 2006 Peter Rosenbaum et al.)

1. Motor abnormalities

A. NATURE AND TYPOLOGY OF THE MOTOR DISORDER:

The observed tonal abnormalities assessed on examination (e.g. hypertonic, hypotonic) as well as the diagnosed movement disorders present, such as Spasticity, ataxia ,dystonia, athetosis. .Individual with CP have traditionally been grouped by the predominant type of motor disorder with a mixed category available in those cases when no one type dominates. This category has been adopted by the classification system described in The Reference & training Manual of Surveillance of Cerebral Palsy in Europe (SCPE) which describe cp in three groups based on pre dominant neuromotor abnormality- spastic, Dyskinetic ,Ataxic. With dyskinesia further differentiated into Dystonia & Choreoathetosis. Mixed should not be used with out elaborating –the component of motor disorder.

COMPONENTS OF CERBRAL PALSY CLASSIFICATION

B. FUNCTIONAL MOTOR ABILITIES: The extent to which the individual is limited in his or her motor function, including oromotor and speech function. The WHO International Classification of functioning, Disability & Health (ICF) have sensitized health professionals consequences of different Health states ,The functional consequences of involvement of upper & lower extremity should therefore be separately classified using objective functional scales. Like- for the key function of ambulation, the gross motor function classification system –(1-5)

2. Accompanying impairments

The presence or absence of later-developing musculoskeletal problems and/or accompanying non-motor neurodevelopmental or sensory problems, such as seizures, hearing or vision impairments, or attentional, behavioral, communicative and/or cognitive deficits, and the extent to which impairments interact in individuals with cerebral palsy.In many individual with CP other impairments interferes with the ability to function in daily life & may at the time produce even greater activity limitation that the motor impairments that are the hallmark of CP.Impairments are Seizure disorders, hearing & visual problems ,cognitive & attention deficits, emotional & behavioral issues & later developing musculoskeletal problems. These impairments should be classified as present or absent, & if present the extent to which they interfere with individual’s ability to function.

3. Anatomical and neuro -imaging findings

A. ANATOMIC DISTRIBUTION: The parts of the body (limbs, trunk,

bulbar region, etc.) affected by motor impairments or limitations. All body region –trunk ,each limb, & or pharynx need to be described individually interms of any impairments of movement or posture.It is recommended that the terms diplegia /quadriplegia not be used until more precise terminology evolves & gains similar acceptance. Those who continue to use these term should define exactly what is meant by them & the characteristics the term described.

B. NEURO-IMAGING FINDINGS: The neuroanatomic findings on CT or MRI imaging, such as ventricular enlargement, white matter loss or brain anomaly. The recommendation of American academy of Neurology to obtain Neuroimaging findings on all children with CP should be followed whenever feasible.

4. Causation and timing

Whether there is a clearly identified cause, as is usually the case with post-natal CP (e.g. meningitis, head injury) or when brain malformations are present, and the presumed time frame during which the injury occurred, if known. Timing of insult should only be noted when reasonably firm evidence indicates that the causative agent are major component of the cause was operative in a specific time window. as for example. with post natal meningitis in previously well infant.

DEVELOPMENT OF LOCOMOTION

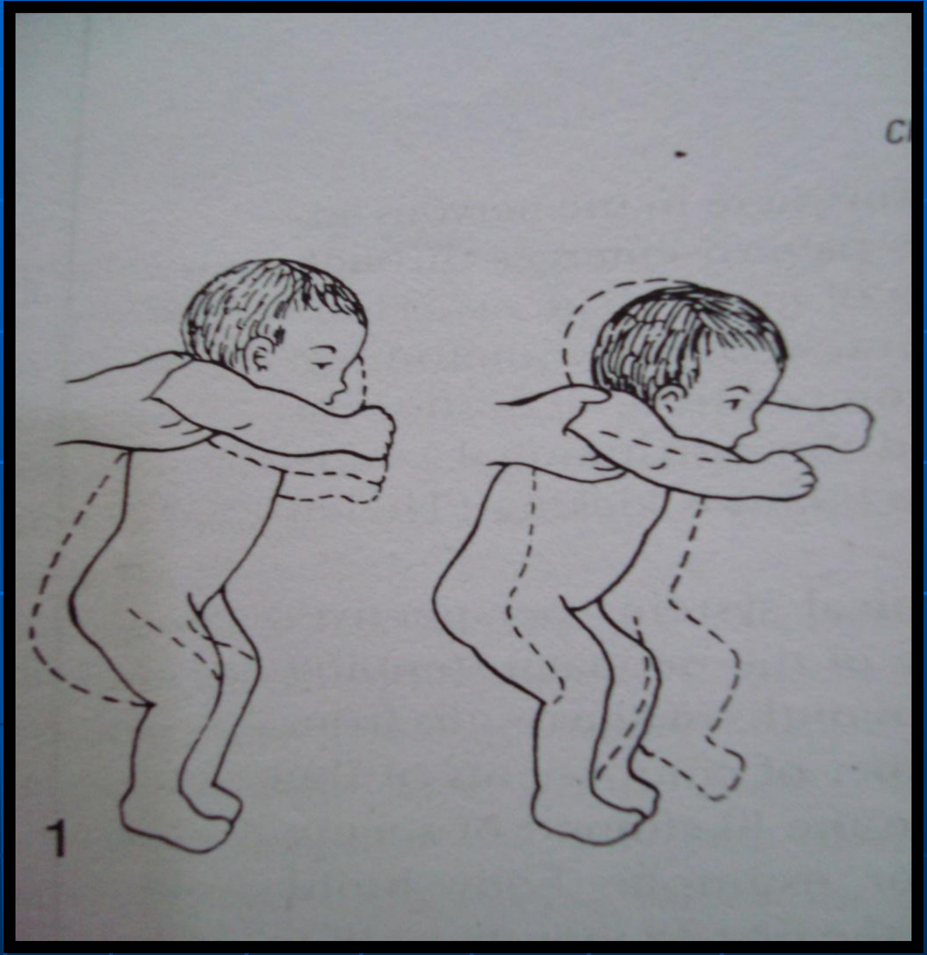
Independent locomotion is an intricate motor tusk .A child learning to walk must activate a complex pattern of muscle contractions in many body segments to produce a coordinated stepping movements, resulting in progression. The child must be strong enough to support body weight & stable enough to compensate for shifts in balance while walking to accomplish the goal of stability. Finally the child must develop the ability to adapt gait to changing environmental circumstances, allowing navigation around & over obstacles & across uneven surfaces. *(Thelen &Ulrich 1991)*

What are the origines of this behaviour during prenatal development ?

Isolated leg & arm movements develop in the embryo by 9 weeks of age, while alternating leg movements ,similar to walking movements seen after birth, develop in infants by about 16 wks of embryonic age ***(De Vries et al1982,Prechtl1984).***Detectable limb movements appear to emerge in a cephalocaudal sequence with movements in the forelimb proceeding those in hind limbs (Bradley & Smith 1988)Finally inter limb coordination develops ,first with alternating pattern ,then with synchronous patterns. *(Stehouer & Farel 1984)*

EARLY STEPPING BEHAVIOR

Stepping becomes progressively more difficult to elicit during first month of life & disappears in most infants by about 2months of age, reappearing many months latter with the onset of self generated locomotion.



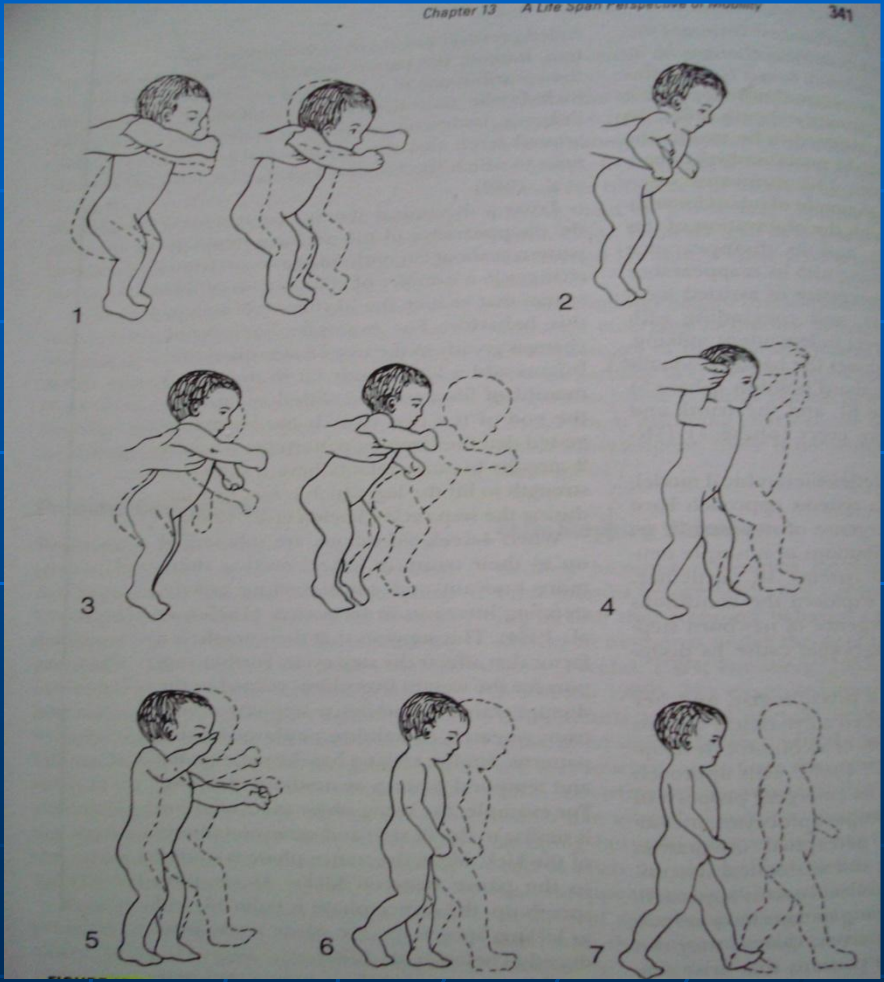
What cause this changes?

According to the reflex hierarchy perspective,new born stepping is thought to result from a stepping reflex.It's disappearance is assumed to be mainly the result of inhibition by maturing higher neural centers.

It has been suggested that the stepping pattern goes away at 2 months because infants have sufficient strength to lift the leg, which is now heavier, during the step cycle(Thelen et al 1989)

PHASES IN DEVELOPMENT OF INFANT LOCOMOTION

- Observation with stepping reflex(ph1)
- Its disappearances(ph2)
- Its reappearences(ph3)
- The emergence of assisted locomotion(ph4)
- Three phases of erect independent walking(ph 5-7)In last three phases the hands gradually move from a high guard position(ph5) to the side(ph6) & the trunk & head become more erect(ph 7)

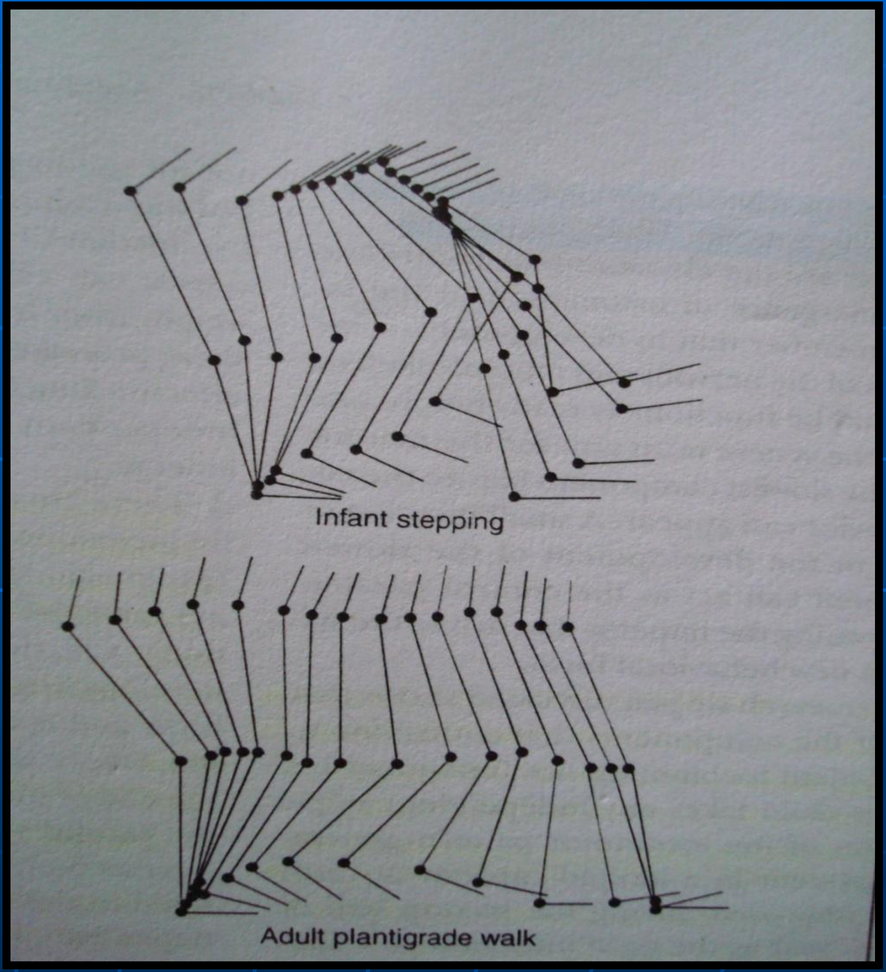


LOCOMOTOR PATTERN CHANGE OVER THE FIRST 2 YEARS OF DEVELOPMENT

Forssberg's research has examined how the loco motor pattern changes using electromyography & motion analysis.

The infant shows high levels of hip flexion compared to the adult.In the neonates, the motor pattern was characterized by a high degree of synchronized activity. In neonates, the extensors muscles of different joints were active simultaneously,& there was much co activation of agonist & antagonist muscles at each joints. The EMG patterns began to look more mature during latter part of second year, with asynchronous patterns emerging at the joints (Forssberg 1985)

Stick figures taken from motion analysis of one step cycle of walking in an infant vs. adult



Requirements for successful locomotion

- A rhythmic stepping pattern (progression).
- The ability to modify gait (adaptation).
- The control of balance (stability).

A rhythmic stepping pattern develops first. It is present in limited form at birth & is refined during the first year of life. Stance stability develops second, toward the end of 1 st year & the beginning of the 2 nd year of life. It appears that adaptability is refined in the first years after the onset of independent walking.

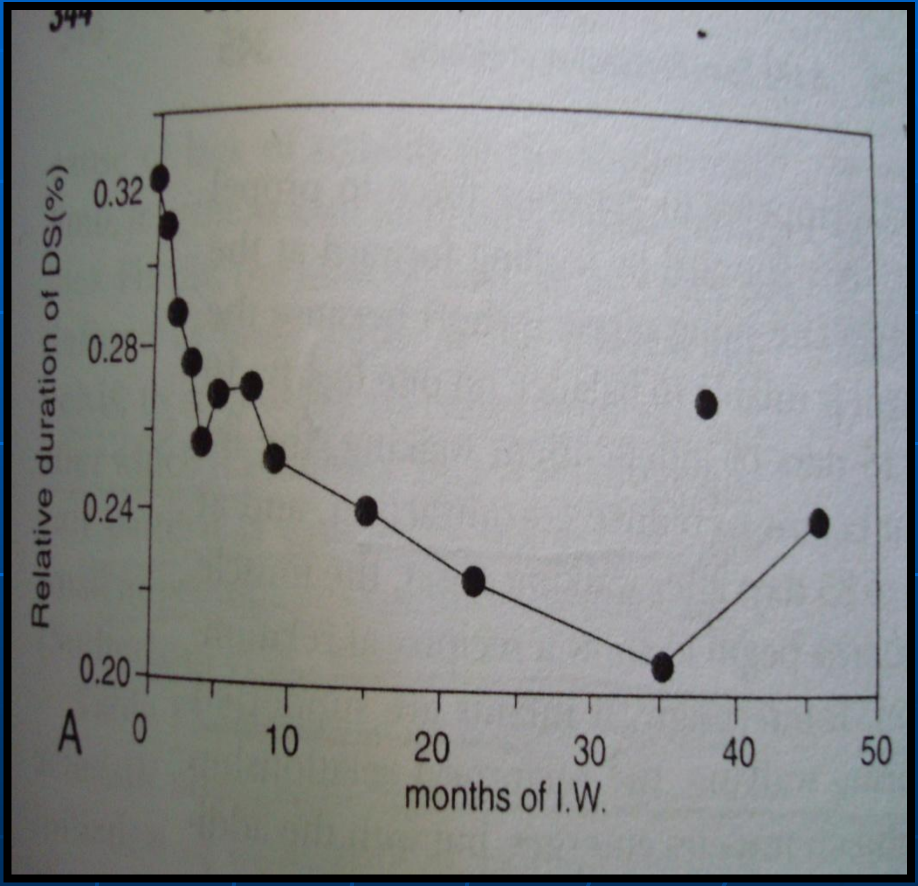
MATURATION OF INDEPENDENT LOCOMOTION

Learning to walk is a two stage process (Brail&Breniere 1993,1998)In the initial phase(3-6 month after onset of walking) Infants learn to control balance,& in the second phase ,which lasts through 5 years of independent walking,the locomotor pattern is progressively refined.

They studied children longitudinally during the 1st 6 years of life to see how gait pattern change as independent locomotion develops.

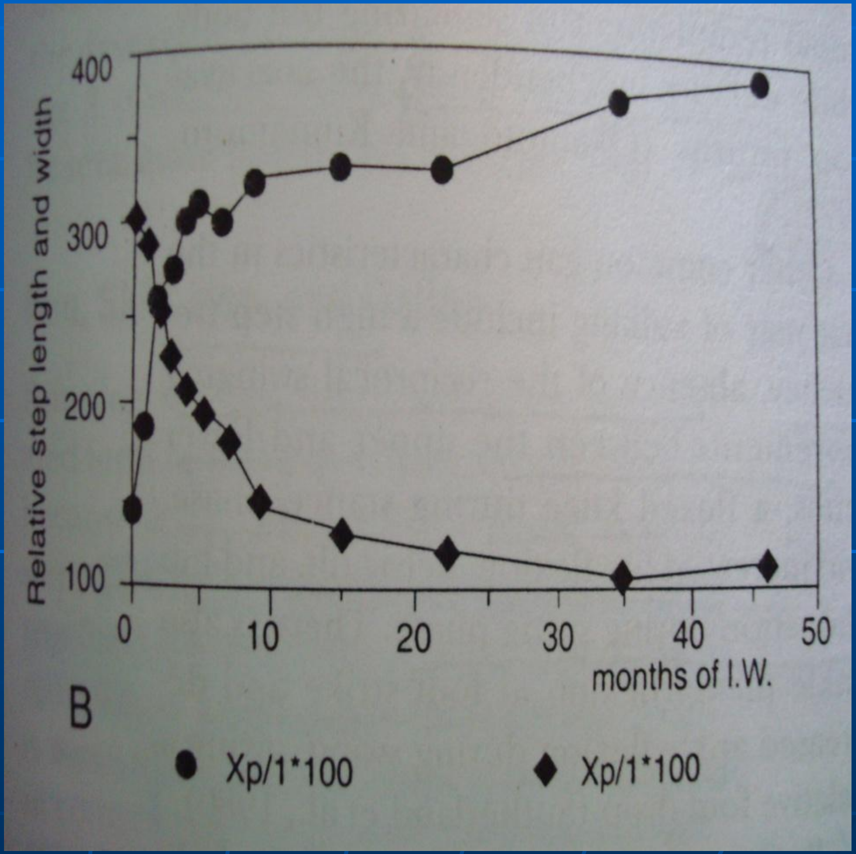
CHANGES IN WALKING PARAMETERS DURING THE 1ST 4 YEARS OF WALING

- The relative duration of double support phase. this picture shows the decrease in the duration of the double support phase of gait that shows a dramatic drop in 1st 4 months of walking, then continues to drop until about 35 months of independent walking.

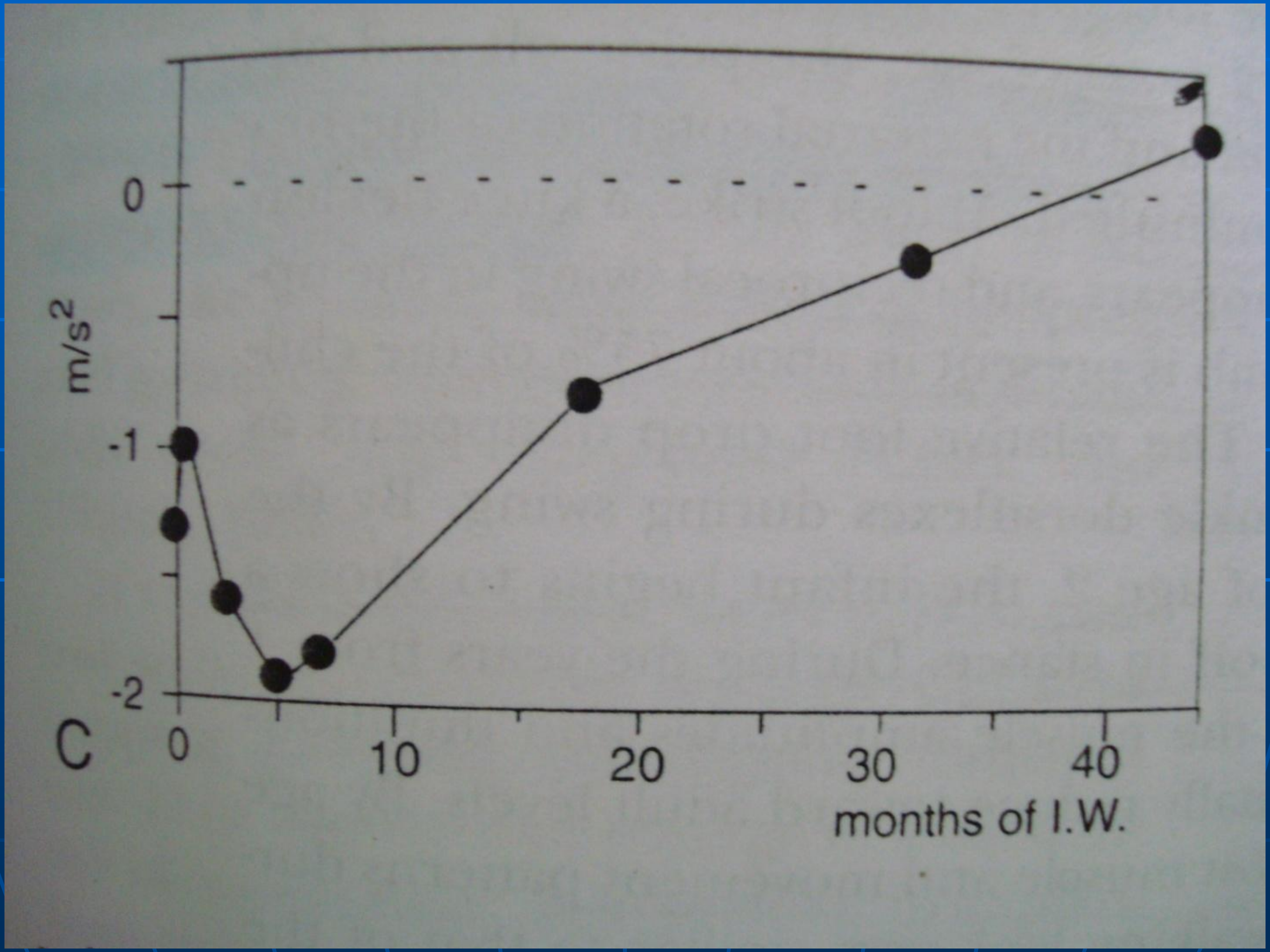


CHANGES IN WALKING PARAMETERS DURING THE 1ST 4 YEARS OF WALING

Changes in relative step length & width. The pic shows the dramatic increase in step length that occurs in the 1st 4 month of walking, along with a decrease in step with that continues through about 10 months of walking. They noted that in newly walking children, velocity was very low, with the swing phase very shot & double support phase long.



Changes in vertical acceleration of the center of gravity.



CHANGES IN WALKING PARAMETERS DURING THE 1ST 4 YEARS OF WALKING

Changes in vertical acceleration of the center of gravity.This pic shows that at the onset of independent walking,the vertical acceleration of the COM at heel strike was always –ve.,indicating an initial deficit in muscular capacity.In the initial 5 month of independent walking the infant increased walking velocity substantially,in large part by increasing step length.This increases the vertical instability& vertical acceleration of COM becomes more –ve.During this period muscle strength appears to remain low compare to balance requirements. By 6 month independent walking the vertical acceleration of COM at heel strike shows a change towards the +ve value, indicating a change in postural control. The vertical acceleration of COM at heel strike finaly reached 0 value at about 3—4 yrs of walking experience, showing that they could control the inertial & gravity forces induced by walking. By 5 years of walking experience 3 of 5 children showed +ve values similar to those of adults.

Developmental sequences for walking

Study of changes in EMG characteristics & kinematics from the onset of walking through the mastery of mature forms of gait have been performed by 0other laboratories *(Okamoto & Kumamoto1972,Sutherland et al 1980)*

In the first day of independent walking

- stepping patterns are immature.
- Push off motion in the stance phase is absent.
- Step is very wide.
- Arms are held high.
- The infant appears to generate force to propel the body forward at the trunk.

Developmental sequences for walking

- The swing phase is short because the infant is unable to balance on one leg.
- By10-15 days of independent walking,the infants begin to reduce cocontraction &50-85 days of walking onset the muscle patterns begin to show a reciprocal relationship.
- A high step frequency Absence of reciprocal swinging movements bt upper &lower limbs,
- A flexed knee during stance phase.
- Increased hip flexion ,pelvic tilt ,hip abduction during swing phase.
- Ankle planter flexion at foot strike & decreased ankle flexion during swing ***.(sutherland et al 1980)***

Developmental sequences for walking

- By2 yaers of age ,the pelvic tilt & abduction & exter rot pf hip are diminished.
- At foot strike a knee flexion wave appears.
- Reciprocal arm swinging in the upper limb is present in about 75% of children.
- The relative foot drop disappears as the ankle dorsiflexes during swing.
- By the end of 2 years the infant begins to show a push off in stance.
- By the age 7 most muscle & movement patterns during walking look very similar to that of the adult *(Sutherland et al 1980)*

IMPORTANT CHARACTERISTICS THAT DETERMINE MATURE GAIT

Sutherland et al (1980) list five important characteristics that determine mature gait, including

- Duration of single limb stance.
- Walking velocity.
- Cadence.
- Step length.
- The ratio of pelvic span to step width.

Duration of single limb stance increases steadily from 32% in 1 yr old to 38% in 7 yrs old.(39% is adult value),

Walking velocity & cadence decrease steadily, while step length increases. Step length is short in the newly walking children because of lack of stability of supporting limb. lengths with increasing balance abilities.

The ratio of pelvic span ,which is defined as body width at the level of pelvis ,to step width increases until age 2.5.after which it stabilizes.

By 3 years of age the gait pattern is essentialy mature. Though small improvement continue through age 7*.(Sutherland et al 1980)*

Characteristics of gait in children

A

Parameter	*Characteristic*	*Normalizes at age*
Step length	Short	15
Step width	Increased	4
Cadence	Increased	15
Speed	Slow	15
Stance	Longer	4
Muscle activity	Increased	4
Heel strike	None	2-3
Knee flexion	Minimal in stance	2-3
Legs	External rotation during swing	2-3
Arm swing	Absent	4

REFINEMENT OF GAIT BY AGE

From Birth to age 9 month

The body structure of infant as they develop the ability to stand upright with support & to cruise independently affects their posture &movement patterns. Femoralantevertion,Femoral antetortion of the hips are both present ***(Bleck1982).***Structuraly the knees in the frontal plane exhibits genu valgum,or bowing in the tibiofemoral angle(Tachdjian1990).A medial inclination of talo-tibial articulation is present in infant,producing an everted talocrural mortise*(Bernhardt1988)*.The medial inclination of the joint is manifested in an everted heel position in weight bearing. Supported walking at this age is characterized by wide abduction, external rotation,& flexion at *hips(Bly 1994)bow* legs,& an everted heel posiution.The frequency & amount of practice of activities such as kicking have been shown to affect the age of onset of ambulation, both in disabled & non disabled infants(Ulrich &Ulrich1995).Infants of 8 months of age exhibits the ability to rise from a kneeling to standing position, which requires closed chain hips & knee extention.Cruising along furniture builds strength of hip abductors *(Bly1994)*

AGE 9 TO 15 MONTH

Onset of ambulation is characteristics by a standing posture with a wide base of support & hips in abduction, flexion,& slight external rotation. The tibia display mild int rotation& varus is still present in tibiofemoral angle in & heel position in weight bearing remains averted because of inclination of mortis joint. The pattern displayed by a beginning walker is small steps ,a widened base of support,& maintenance of body & limbs very upright in an extended, stiff position. According to Sutherland & his colleague (1988) characterizes infant ambulation consisting of a wide base of support, increase hip & knee flexion, full foot initial contact in planter flexion, a short stride, increase cadence & a relative foot drop in swing phase. The electromyography patterns of activity at the onset of independent ambulation demonstrate significant co contraction in antagonistic muscle groups & anterior tibialis & gastrocnemius during swing phase & quadriceps & hamstrings muscles during stance phase.

(Thelen & coocke 1987).

AGE 18 to 24 MONTH

By 18 month of age ,the varus angulation of tibiofemoral angle in the frontal plane has resolved & the limb is straight. A heel strike has not consistently emerged in the 18 month old child ***(Sutherland 1988),***but the lessened base of support allows for more anterior posterior movement over the planted foot. heel position remains everted***.(Valmassy1984).*** A knee flexion wave begins to emerge during initial stanse phase remains prolonged & cadence is increased relative to mature gait. A consistent heel strike develops by 24 months of age ***(Sutherland1988).***Children with impaired walking ability lack a heel strike at initial contact. This may be caused by either lack of motor control or the inherent choice of maintaining stability by use of a larger area of initial contac. ***(Gage1991)***

AGE 3 TO 3.5 YEARS

Between the ages of 3 & 3.5 years ,the joint angles associated with walking mature into the the aduld pattern ***(sutherland 1988)*** .Structurally the tibiofemoral angle ,which was neutral at 18 months of age, now shows maximum valgus alignment .Femoral antetortion of the hip is decreasing but remains in decreased in relation to that measured in an adult. Heel Evertion in weight bearing can still be observed but is decreasing in motion analysis demonstrates that a heel strike is consistently present in conjunction with a knee flexion wave in early stance***.(Sutherland1988).***

AGE 6 TO 7 YEARS

By age 7 years the gait patters by standards of movement or motion are fully mature. Although time & distance variables continue to vary with age & statuire*.(Sutherland1988*).Structeraly the tibiofemoral angle has return to ***neutral*** *(Techdjian1990).*The femoral antevertion is largely resolved but still slightly higher than the measured in adult (Bleck1987)The inclination of tibiofemoral joint is no longer present, & heel position is neutral by age 7 ***(Valkmassy 1984) .***

Classification

The most commonly accepted classification of gait in spastic hemiplegia by is that reported by *Winters et al (1987).* they subdivided hemiplegia into 4 gait pattern based on analyzing kinematics data in sagital plane & electromyographic data. The class has direct relevance to understanding the gait pattern & management. ***(WINTERS, GAGE, HICKS1987)***

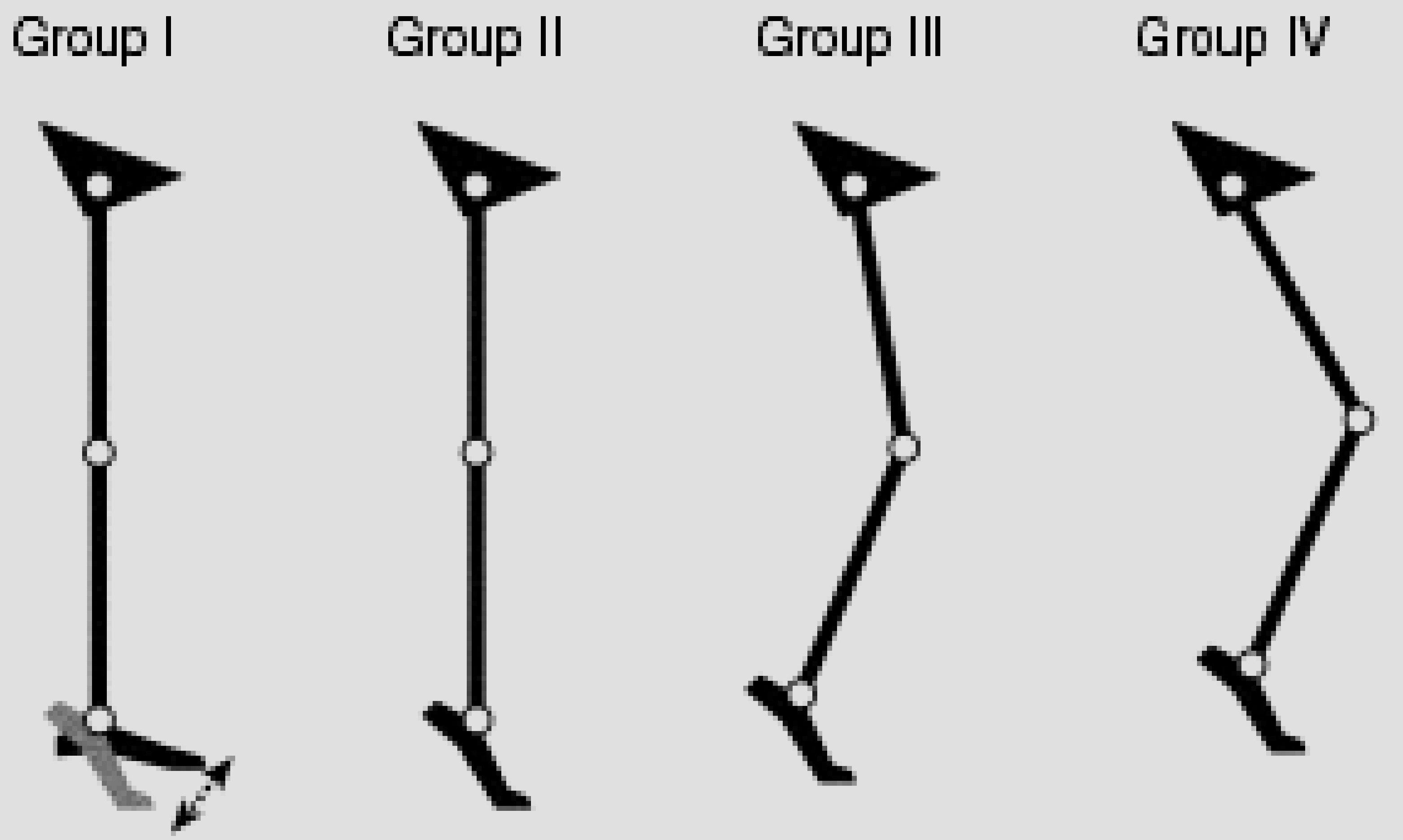
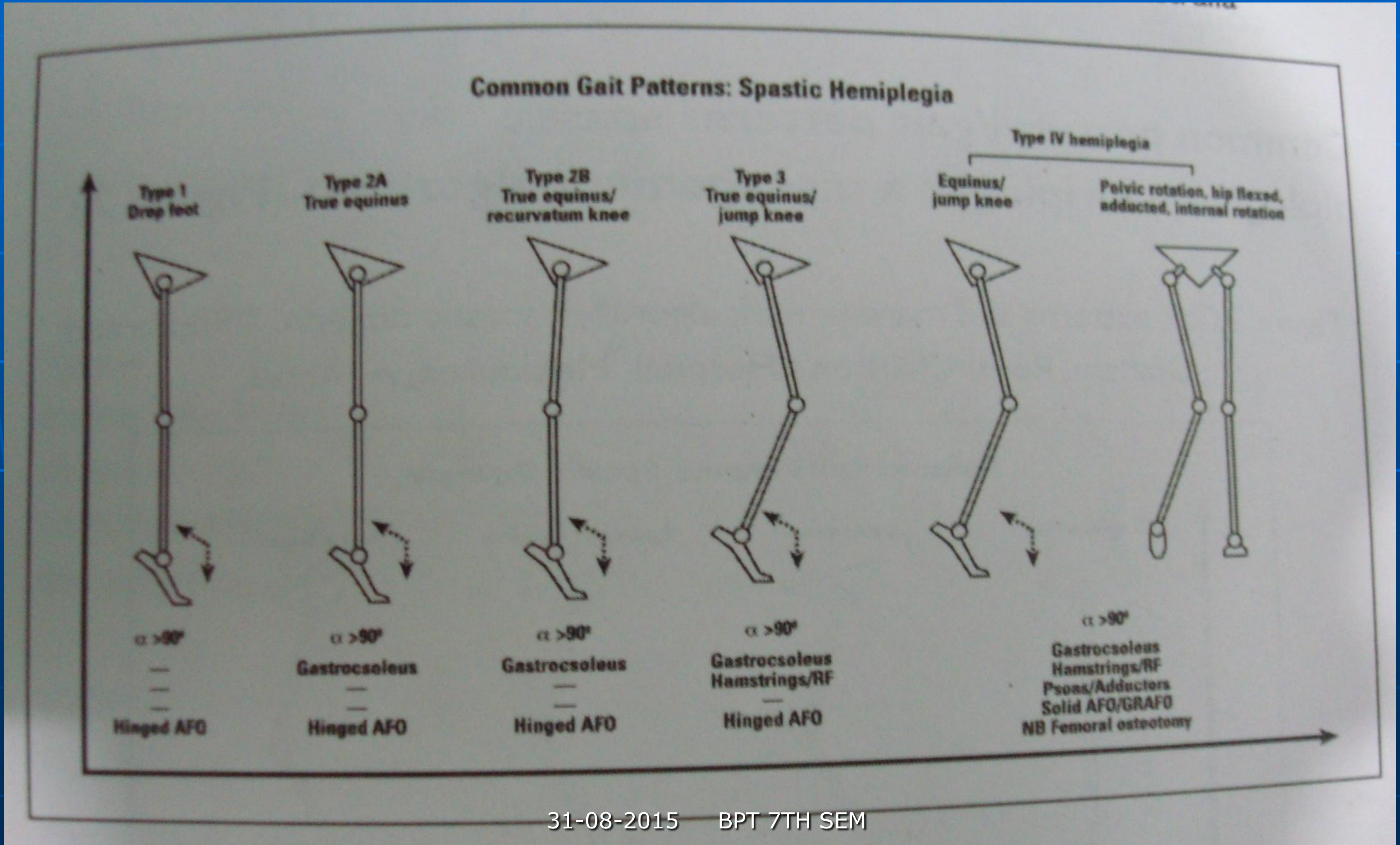


Figure 2: *Diagrammatic representation of postures of four groups on the Winters et al. (1987)[11] classification.*

Common Gait Pattern Spastic Hemiplegia (Rodda & Graham)



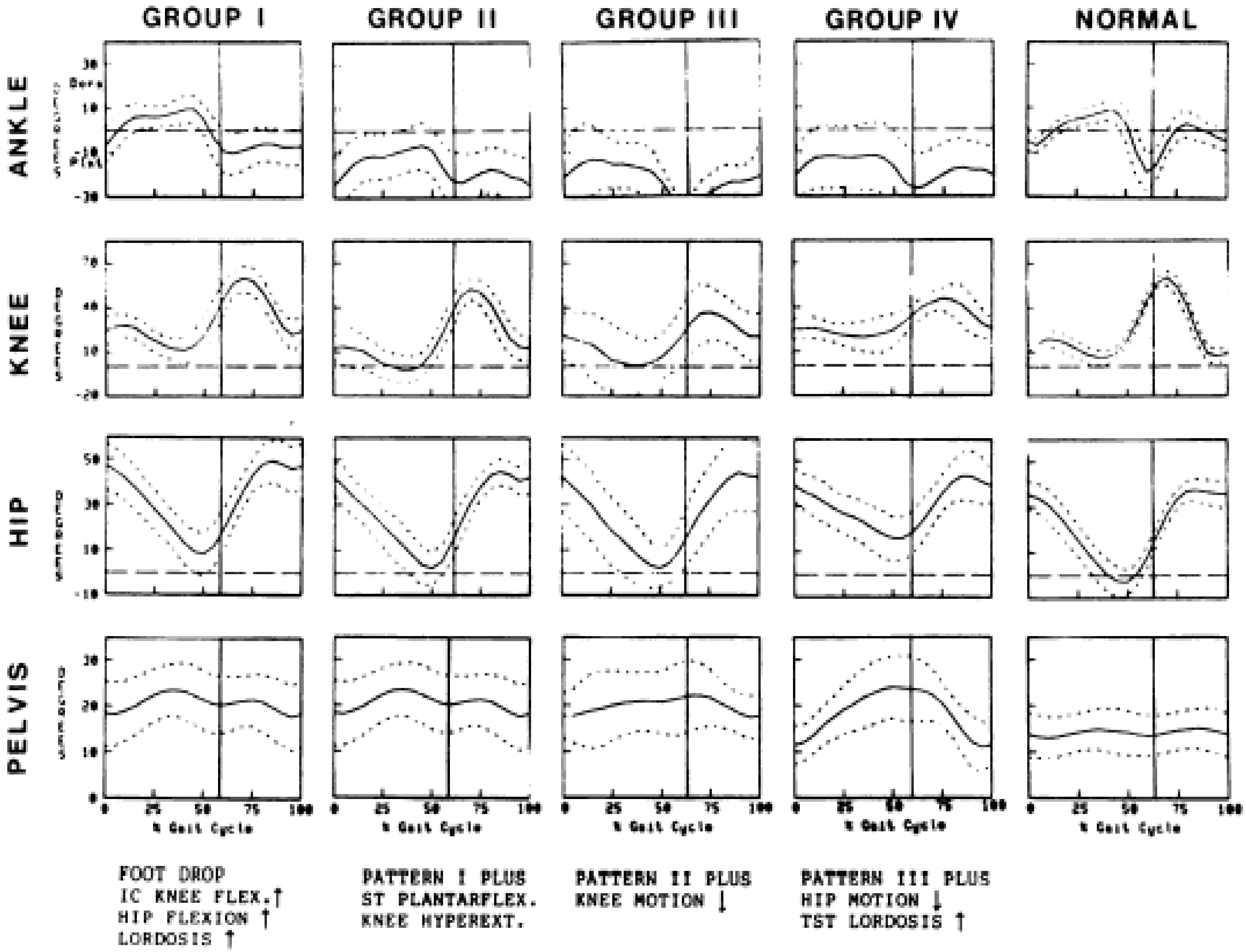


FIG. 1

The charts indicate the mean (solid line) and standard deviation (dotted line) of motion of the joints in the sagittal plane for each group and for normal values. Features of each group are summarized at the bottom of the chart using the following abbreviations: IC = initial contact, ST = stance, and TST = terminal stance.

TYPE 1 HEMIPLEGIA

The most significant abnormality of gait was a drop foot in the swing phase (plantar flexion of the ankle in the swing phase, resulting in an equines deformity at initial contact), but equally important was the finding that they had an adequate range of dorsiflexion (average, 12 degrees) . The heel cord was not tight since there was adequate dorsiflexion in the stance phase .The amount of dorsiflexion in the stance phase was more than zero degrees in all of the Group-I patients. To compensate for the drop foot, the knee hyper flexed at foot strike, forcing the hip into increased flexion in order to maintain the body in a position centered over the foot and to help clear the swinging limb with the drop foot. The pattern of pelvic tilt showed increased lordosis throughout the gait cycle

MANAGEMENT SUMMARY

The classic treatment for these patients has been to lengthen the heel cord. Such treatment, however, can worsen the gait since the pathological lesion is not a shortening of the gastronomies and soleus muscles as evidenced by dorsiflexion of more than zero degrees during the stance phase. It is more likely that the problem is weakness or under activity of the anterior tibial muscle relative to overactivity of the gastronomies and soleus muscles.

<u>Orthotic Management:</u> It is managed by leaf spring or hinged ankle foot orthoses. Type I involves equinus only in swing phase, causing a foot clearance problem, which can be resolved using either a posterior leaf spring (PLS) or hinged AFO with a plantar flexion-stop.

TYPE 2 HEMIPLEGIA

The patients in Group II had a static or dynamic contracture of the gastronomies and soleus muscles that resulted in persistent plantar flexion of the ankle during the **stance** and swing phases. Perry stated that 15 degrees of plantar flexion of the ankle places the trunk behind the foot **unless** the knee is hyper extended, the hip is flexed, or the heel is elevated by external support. When the ankle is in fixed plantar flexion, the tibia and foot function together as a long lever that will not allow the usual rocker motion of the tibia on the foot. This forces the knee into hyperextension in the middle and terminal stages of stance. In addition, advancement of the trunk is curtailed and the length of the opposite step is decreased. To maintain the center of gravity over the foot, flexion of the hip and pelvic lordosis were **increased, as** in the patients who were in Group II. In the study of Knutsson and Richards one-third of the twenty-six patients who had hemiplegia secondary to a cerebrovascular accident demonstrated a pattern that was similar to that in our Group-II patients. The main disturbance was plantar flexion of the ankle that resulted in hyperextension of the knee.

MANAGEMENT SUMMARY

- Type 2 hemiplegia with a fixed contracture of the gastrocnemius constitutes the only indication for isolated lengthening of tendo achillis (Borton et al 2001)If the knee is fully extended or in recurvatum ,then a hinged AFO with an appropriate planter flexion stop is most appropriate choice of orthoses . Equino varas deformity can be managed by concomitant injection (BTX-A) of tibialis posterior at the time of calf injection or by split transfer of tibialis posterior ***(Boyed & Graham 1997).***Older children with progressive vulgar deformity are likely to become intolerant & require bony surgery such as os calcis lengthening or subtalar fusion. *Miller et al –(1995).*
- **Spasticity management:** BTX-A.
- **Contracture management:**Tendo Achilles lengthening. Strayer calf lengthening, if the contracture is confined to the gastrocnemius.

MANAGEMENT SUMMARY

<u>Orthotic Management:</u> Hinged AFO or leaf spring AFO. For type II hemiplegia, when equinus persists in both stance and swing phase and the knee tends towards hyperextension during stance, an appropriately tuned rigid AFO is recommended. A hinged AFO with a plantar flexion-stop might be preferred by some prescribers providing there is a reasonable range of dorsiflexion with the knee extended.

TYPE 3 HEMIPLEGIA

The musculature in the proximal part of the lower extremity was more involved in the patients in Group III than in those in Groups I and II. Waters et al believed that the stiff-legged gait of some hemiplegic patients is a regression to primitive locomotor patterns. These patterns are present in quadrupeds that depend on the extensor reflex for stability in stance and activation of the lowerextremity. This extensor reflex occurs during terminal swing phase. There is a strong reflexive tie between contraction of the quadriceps muscles, extension of the hip, and plantar flexion of the ankle; therefore, the equinus position is normal during gait in quadrupeds. In bipeds, the extensor reflex at the ankle has been blocked so that humans do not normally initiate the stance phase with the foot plantar flexed.

TYPE 3 HEMIPLEGIA

In the Group-III patients the extensor reflex remained at the hip and knee to resist the flexor thrust; in fact, extensor tone is enhanced when one rises to the upright position. A central lesion in Group-III patients released the plantar reflex at the ankle from its inhibitory block. The result was the stiff gait with short steps that the Group-III patients demonstrated. In the Group-Ill patients, however, the quadriceps and hamstring muscles remained active. This simultaneous contraction of flexor and extensor muscles limited flexion of the knee during swing. Electromyography using surface amplified electrodes confirmed this by showing the abnormal activity of these muscles during the swing phase . They believe that loss of coordinated contraction of the quadriceps and hamstring muscles is the primary cause of the decreased flexion of the knee that occurs during the swing phase6

STIFF KNEE GAIT

TYPE 3 HEMIPLEGIA

Knutsson and Richards also found hyperextension of the knee in the stance phase and decreased flexion of the knee in the swing phase in one-third of their patients. However, they also found decreased electromyographic activity of two or more muscle groups and believed the hyperextension of the knee compensated for weakness of the muscles rather than was secondary to plantar flexor spasticity. Decreased electromyographic activity was not found in our Group-Ill patients. In one-sixth of the patients in their series, Knutsson and Richards found concomitant activation (asshown by electromyography) in four to six muscle groups and decreased flexion of the knee during the swing phase (stiff knee gait).

These findings were true of all of our patients who were in Group III.

MANAGEMENT SUMMARY

- **Surgical Management:** Lengthening of medial hamstrings with transfer of rectus femoris to the semitendinosus is the most effective long term solution for the stiff knee *.(Sutherland etal1990,Chambers et al 1998)*
- **Spasticity management:** femoris have been with little clinical or motion BTX-A to the calf & Hamstring. A injct to rectus Femoris Has been tried with little clinical experience.
- Contracture management:Tendo achilis lengthening combined with lengthening of medial hamstrings & transfer of rectus femoris to the gracilis or semi tendinosus.

MANAGEMENT SUMMARY

Orthotic management : Solid or hinged AFO according to the pre & post intervention integrity of the planter flexion ,knee extension couple. Winters’ types III when additional knee and hip involvement exists, orthotic management may help to resolve the foot and ankle problem but orthopedic surgery is required to resolve the proximal impairments. The use of a knee gaiter to hold the knee extended may help to reduce the rate that a knee flexion deformity deteriorates. In addition to the marital-plane problems there can be a tendency for hindfoot varus if there is Spasticity affecting the tibialis posterior muscle; this can be corrected in the AFO during the casting process and maintained with extra strapping if necessary.

TYPE 4 HEMIPLEGIA

In Group-IV patients, as in Group-III patients, the extensor reflex was implicated because they had decreased motion at the hip and knee and plantar flexion at the ankle. There is marked asymmetry in cluding pelvic retraction for unilateral involvement. The reduction of motion in the sagittal plane at the hip constituted the crucial difference between Groups III and IV. Increased activity of the iliopsoas and hip adductors prevented the hip from reaching full extension at terminal stance phase. The length of the stride would have been severely shortened without the compensatory increase in anterior pelvic tilt. There is high incident of hip Subluxation & careful radiographic examination of hip is important *(Simmons et al 1998)*

MANAGEMENT SUMMARY

Spasticity management : Multilevel injct of BTX-A including calf & hamstring ,sometimes hip adductor & hip flexors.

Contracture /Deformity management: Lengthening of calf & medial hamstring (rectus femoris) hip adductor. Iliopsoas, External osteototomy. Winters' type IV hemiplegia can be associated with femoral anteversion causing an internal rotational foot-progression angle and some compensatory retraction of the pelvis on the affected side. Surgical correction of the anteversion leads to better function and a more symmetrical gait **(Graham et al. 2005)**. Hip subluxation is rarely associated with hemiplegia ***(Soo et al. 2006).***

MANAGEMENT SUMMARY

Orthotic Management: Ground reaction AFO ,Solid AFO, or Hinged AFO ,according to the integrity of plater flexion & knee extention couple. Leg-length discrepancy (LLD) is often associated with hemiplegia but, as it is the weaker leg that is shorter, a small difference may be an advantage for achieving foot clearance in swing phase. Significant LLD causes pelvic obliquity in the coronal plane or compensatory excessive hip and knee flexion of the longer limb. An internal heel elevator or external shoe raise can then be used to fine tune the effect of the ground reaction force on the knee and hip joints, further enhancing gait efficiency. If necessary the LLD can be addressed surgically by epiphysiodesis to arrest growth in the longer limb at an appropriate age.

MANAGEMENT SUMMARY

The upper limb is also affected in hemiplegia and a wrist hand orthoses (WHO) leaving the fingers and thumb free sometimes helps to improve function by holding the wrist in a functional position; and a paddle-type design can be used to stretch the whole wrist and hand. A stiffened fabric gaiter can be used for short periods to stretch the elbow if flexion deformity occurs. There has been renewed interest in constraint induced therapy to disable the good hand in an effort to encourage use of the impaired side ***(Eliasson et al. 2005,Naylor and Bower 2005).***

COMMON POSTURAL /GAIT PATTERN IN SPASTIC DIPLEGICS/QUADRIPLEGICS

The pattern of knee involvement in spastic diplegic described by Sutherland & Davids are excellent basis for classifying postural & gait pattern in spastic diplegic ***(Suyherland & davids,1993).***The most common gait abnormality of knee in patient with cerebral palsy occur in the sagittal plane. The four primary gait abnormality of knee are: Jump knee, Crouch knee, Stiff knee & Recurvatum knee. They have described each abnormality by it’s motion analysis laboratory profile (physical examination ,motion parameters, electromyography data,& force plate data).

Classification of gait pattern was based on the position of the ankle in sagittal plane gait in Spastic Diplegia.

Diagrams showing each gait pattern, with the dominant muscle groups identified for the management of Spasticity & contracture & appropriate orthotic prescription. Group 5 is a combination of group 1 to 4,with a different group in lower limb compared with the left lower limb. In this example, the rt lower limb is group 3 .apparent equines, & the left lower limb is group 2 ,jump gait.

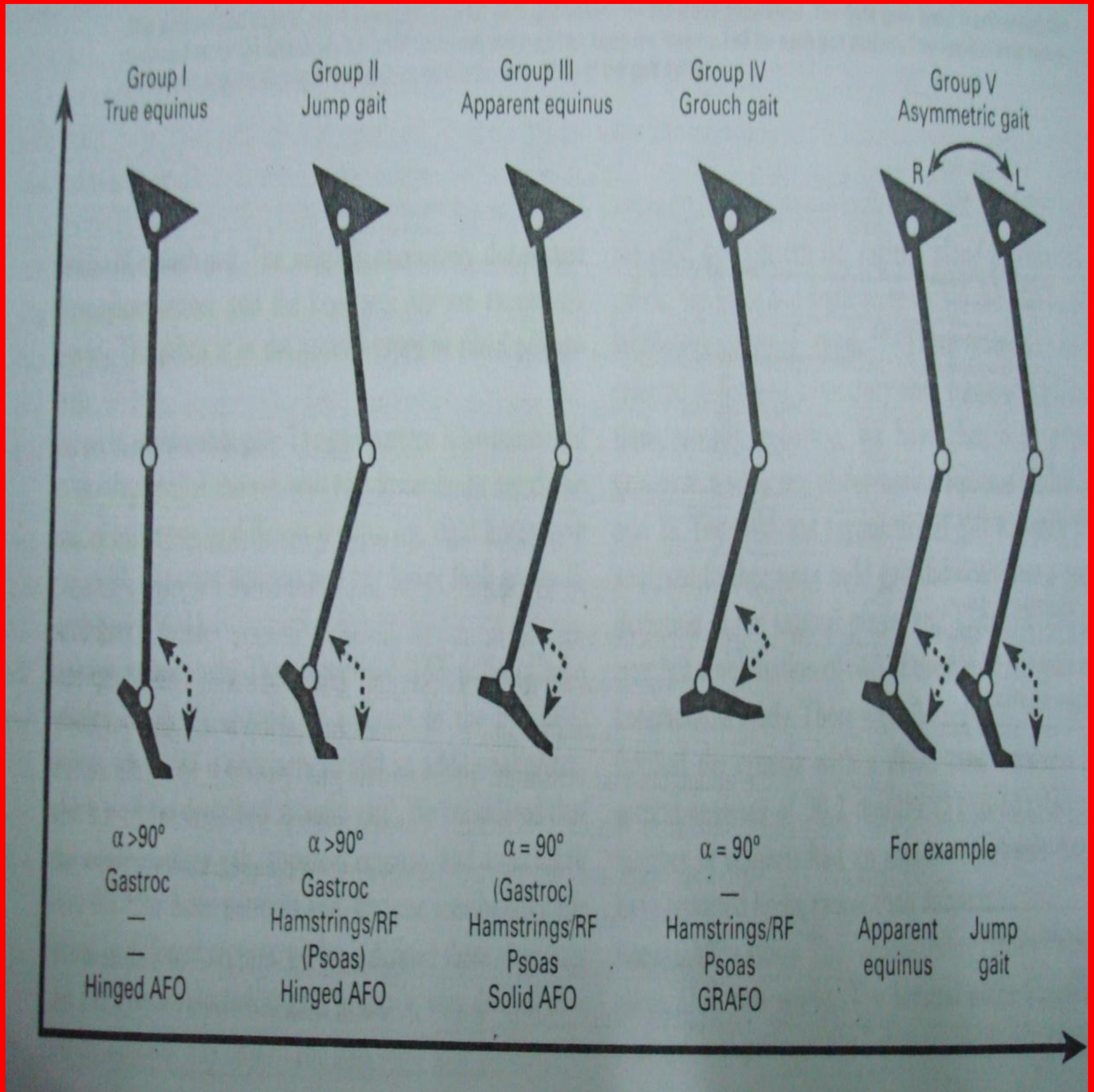


Fig. 1

TRUE EQUINUS

When the younger child with diplegia begins to walk with or without assistance ,calf Spasticity is frequently do dominant resulting in a true equinus gait 'with ankle in planter flexion through out then stance & the hips & knees are extended. True equines may be hidden by the development of recurvatum of knee. The patient can stand with foot flat & the knee in recurvatum ***(Miller et al 1995).***

Recurvatum knee gait describes increased knee extention in mid & lateral stance phase with variable knee motion on swing phase.

Physical examination: Straight leg raise revealed hyper extention of knee. A-P & varus or valgus instability of knee may be present. At ankle an equnius contracture ,often with significant increased tone & clonus is present.

Motion parameters: Sagittal plane kinematics reveal decreased knee flexion beginning in stance phase ,& progressing to hyperextention in mid –to late stance. Sagital pl ankle kinematics reveal an equnius type of planter flexion at foot strike,Loss of early stance phase dorsiflexion,& increased plt flexion in mid & late stance as the knee hyperextends.

ETIOLOGY

ETIOLOGY: Knee hyperextention in mid stance /late stance is usually attributed to triceps surae contracture & over cativity.With an foot rockers creates an early extention moment at the knee. Repeated stress on the posterior str of knee leads to soft tissue stretching & eventual hyperextention. Of knee. Recurvatum knee gait may also be seen after overly aggressive lengthening or transfer of hamstring muscle.

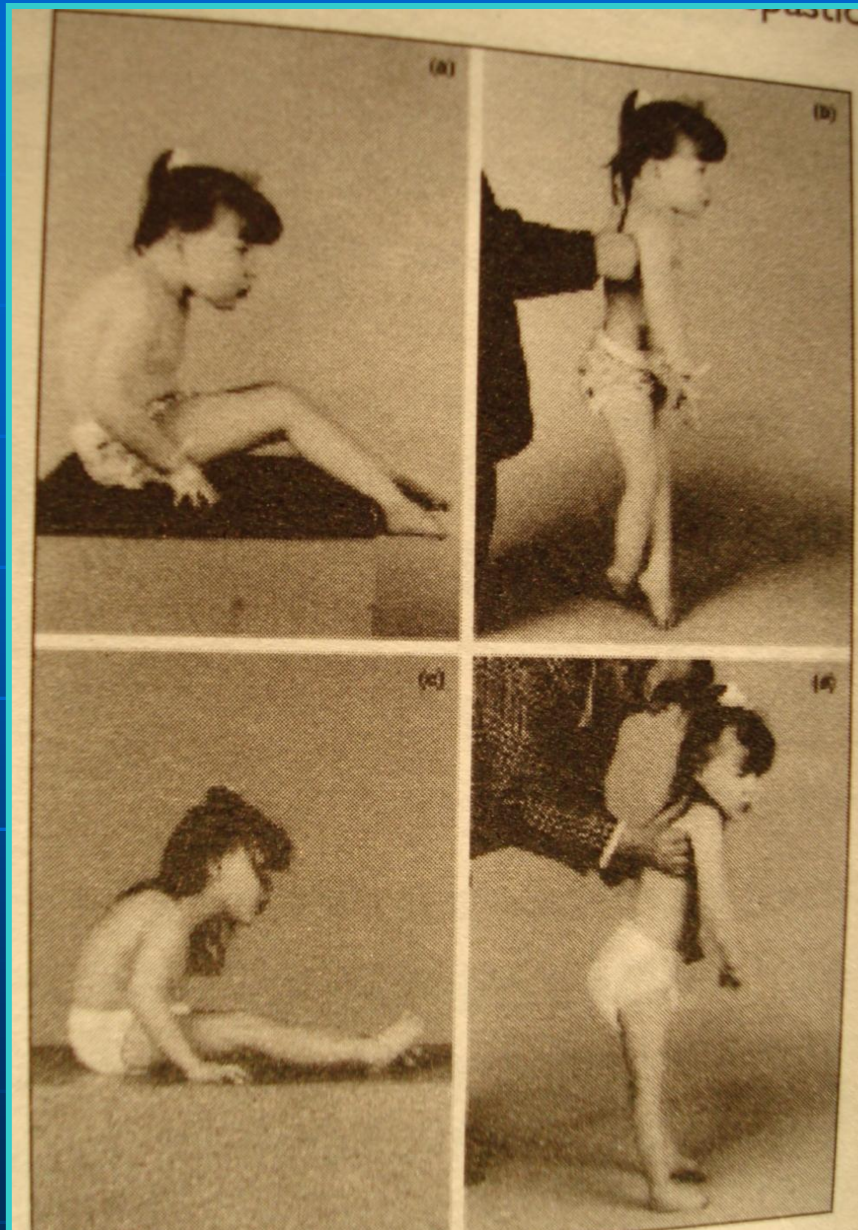
Consequences of gait: Increased extention or hyperextention of knee in stance phase decreased walking velocity by limiting stride length. Forward momentum is disrupted & ambulation becomes less energy efficient. Late anatomic changes are related to posterior soft tissue stretching & can include knee jt instability & possibly degenerative arthritis.

MANAGEMENT SUMMERY

Spasticity management: BTX A_injection on gastroknemious.

Contracture Management: Those who having fixed equines contracture,may be benefited from isolated gastrocnemius lengthening

Orhotic Management: A more stable BOS can be enhanced by the use of hinged AFOs (Buckon et all2001)


(a)
(b)
(c)
(d)


B

JUMP GAIT

Jump gait pattern is very common seen in the children with diplegia.The ankle is equnius,the knee & hip are in flexion, there is ant pelvic tilt & an increased lumber lordosis.The gait is characterized by increased knee flexion in early stance phase, through initial double support, with correction of knee wave to normal or near normal extention in mid & late stance. Diminished knee extention in late swing phase is also present. Over activity of hamstring ms produces increased flexion in late swing & early stance phase. The quadriceps remain competent & planter flexor facilitate knee extention in mid & late stance phase.

Motion lab profile: Mild contracture of hip adductor & hip flexor are present on physical examination. Increased tone of the hamstring .with out contracture is also seen. Quadriceps weakness is occationaly present but it is not a significant contributor to knee flexion.The triceps surae shown increased tone with or with out muscle contracture.

JUMP GAIT

Motor parameter: Hip flexion is exaggerated through out the gait cycle. Full extention in stance is abscent.Sagittal plane knee kinematics reveal increased early, stance knee flexion wave of at least 30`,with extention in mid stance approximately 10-20`.Incomplete knee extention in late swing is also present.Saggital plane ankle kinematic also reveal an slight increased in dorsiflexion in initial stance ,often with out heel strike, because of the increased knee flexion. Pathological progression of dorsiflexion to the time of opposite foot strike ,as seen in progressive crouch gait is not present.Overactivity of the hamstring in seen electromyographically in the stance phase. Prolongation of illiopsoas activity into early & mid stance may also be present.

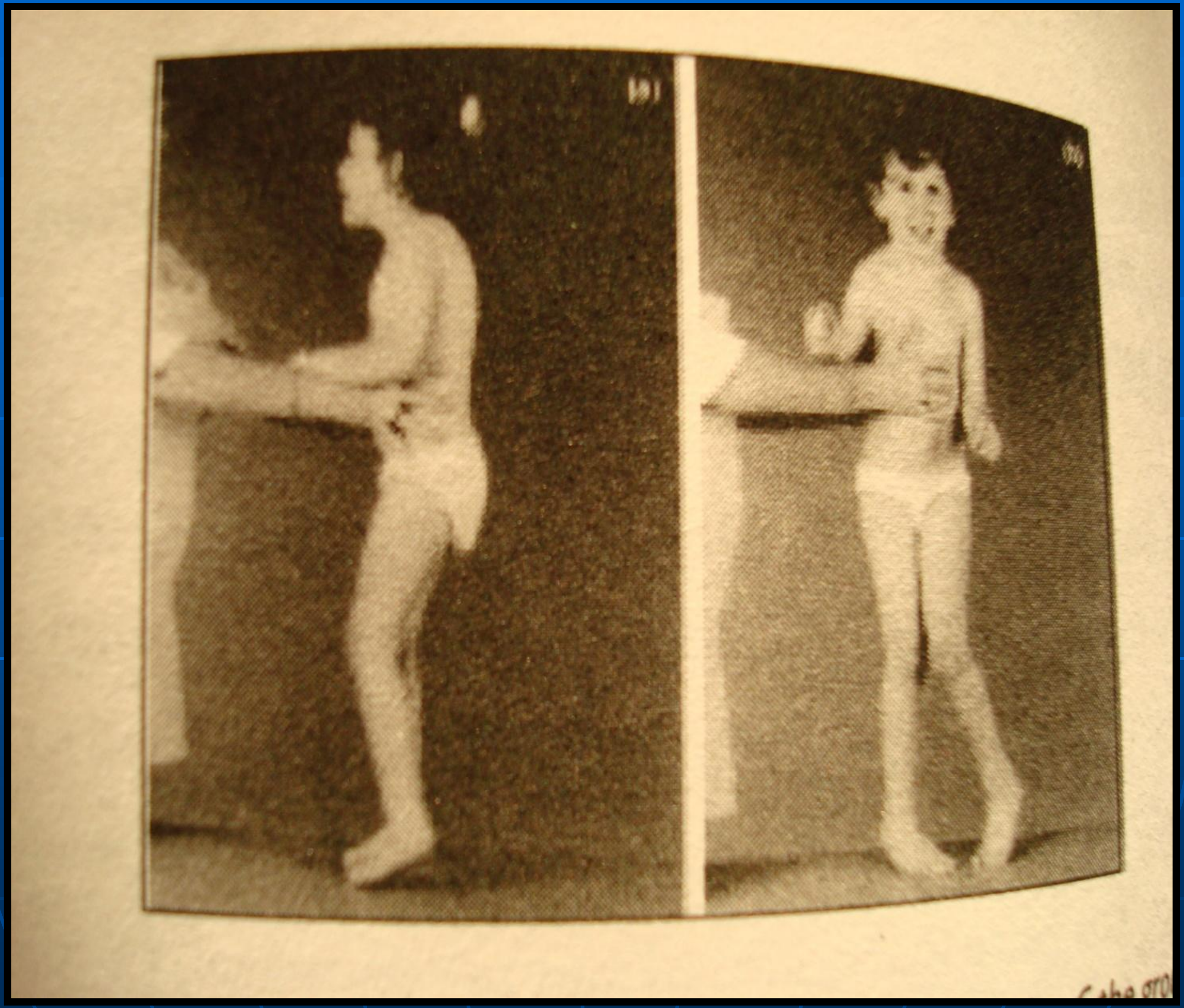
Etiology: Jump gait is usually seen in conjunction with increased contractures of hip adductor / hip flexors & hamstring & /or universal tone.

MANAGEMENT SUMMARY

Spasticity management: In young children, this pattern can be managed effectively by BTX_A inj to the gastronomies & hamstrings & provition for an AFO.A more extensive multi level approach ,but it is not for inexperienced practitioner. (Molenaers et al 1999)SDR may be the best solution to achieve a permanent reduction in tone, provided the appropriate indications are observed ***(Gromly et al 2001).***

Contracture /deformity management: In older children musculotedinous lengthening of the gasrocnemious,hamstring & iliopsoas may be indicated with transfer of the rectus femoris to semitendinosus for co contraction at knee ***(Molenears et al 2001)***

Othotic management: Ground reaction AFO, solid AFO, hinged AFO according to integrity of pf-knee couple.



APPARENT EQUNIUS GAIT

As the child gets older & heavier a number of changes may occur which may render the calf muscle & planter flexion knee extention couple less cometent.Equinus may gradually decrease as hip & knee flexion increased ***(Sutherland & davidds 1993,Molenears et al).***The ankle has normal ROM but the hip & knee are excessively flexed throughout the stance. The pelvis is normal or tilted anteriorly. There is frequently a stage of 'apperent equinus'where the child still noted to be walking on the toes 7 simple observational gait analysis may mistakenly conclude that the equines is real, when it is in fact apperent. ***(Boyd & Graham 1997)Sagital*** plane kinematic show that the ankle has a normal range of dorsiflexion but the hip & knee are in excessive flexion throught the stance phase of gait.

MANAGEMENT SUMMERY

Spasticity management: The hamstring & illiopsoas may benefit from Spasticity treatment or muskulotendinous lengthening ***(Corry et al 1999).*** In youg child BTX_A inj over hamstring & illiopsoas may be helpful.

Contracture & deformity management: Single event multi level surgery, addressing all contractures & lever arm problem.

Orthotic management: Ground reaction AFO. solid AFO, Hinged AFO according to the integrity of the PF-KE couple.

Equinus gait

Table II: Intervention grades by management aims

Aims of treatment	*Physical therapy*	*Orthoses*	*Casting*	*Botulinum toxin A*	*Surgery*
Prevent deformity	C	C	C	B	C
Correct deformity	C	C	A	A	C
Promote a base of support	C	C	C	A	C
Facilitate training of skills	B	C	C	B	C
Improve efficiency of movement (gait)	C	C	B/C	A/B	C

A, Level I/Grade A (large randomized trials with clear-cut results); B, Level II/Grade B (small randomized trials with uncertain results); C, Levels III, IV, V/Grade C (non-randomized, and no controls).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C

CROUICH GAIT

The ankle is excessively dorsiflexed throughout stance & the hip & knee are excessively flexed. The pelvis is in the normal range or tilted posteriorly.This pattern is part of the natural history of gait disorder in children with more severe diplegic & in the majority of children with spastic quadriplegia.

Physical exam: Hamstring contracture is commonly seen. Straight leg raise & popliteal angle measurment s are most sensitive test. Quadriceps weakness as reflected by a knee extention lag, may also be seen. When present the patella alta reflects functional lengthening of patella tendon by overuse & stretch. Triceps surae weakness or contracture or both may also be present. Weakness is demonstrated by decreased ability to perform toe rises. Contracture can be examined by examining ankle range of motion with both knee flexed & extended.Illiopsoas contracture ,reflected by diminished hip extention is variable. Excessive pes valgus or increased external tibial torsion may be present & the presence of either contributes to exaggerated stance knee flexion.

MOTION PARAMETER

Sagital plane knee kinematics show increased knee flexion of at least 30` throughout the stance phase. Diminished knee extention on late swing phase will also be present when the primary cause is hamstring contracture.Sagital plane ankle kinematics revel increased ankle dorsiflexion in stance phase. When attributable to tricepsurae weakness, the ankle dorsiflexion will be progressive in stance until opposite foot strike. When attributable to triceps surae contracture, the ankle dorsiflexion will be constant throughout the stance phase, to limit the contracture.Sagittal plane hip kinematics will exhibit increased hip flexion through out the stance phase. when illiopsoas contracture is present. Stance phase prolongation of quadriceps & hamstring activity are present in electromyographic study.

ETIOLOGY

Commonest cause of crouch gait in children with spastic diplegic is isolated lengthening of the heel cord in younger child ***(Sutherland& cooper1978,Borton et al 2001)*** Once the heel cord has been lengthened ,if the Spasticity /contracture of the hamstring & iliopsoas has not been recognized & is not managed adequately ,there will be rapid increased in hip & knee flexion ***(Miller et al 1995).***The primary contractures of the hamstrings with /with out contracture of the hip flexors, are the most common causes of crouch knee gait. This pattern may also be iatrogenic, as primary hamstrings contractures seen injudiciously or isolated lengthening of contracted triceps surae.

COSEQUENCES FOR GAIT

Increased knee flexion throughout then stance phase results in a continuous flexion moment about the knee leading to excessive demand on quadriceps. The knee extensor mechanism causes stretching, leading to patella alta & alteration of patellofemoral & tibiofemoral jt mechanics. Increased joint reaction force lead to late patellofemoral degenerative changes. When decreased knee extention in late swing is also present, stride length will be shortened, resulting in decreased velocity. Compensatory effects such as decreased stride length, degreased single limb stance time & excessive arm swing reflect efforts to unload the quadriceps by minimizing the flexion moment

MANAGEMENT SUMMERY

Spasticity Management: In younger children BTX-A injection to the Hamstring & hip flexors.

Contracture /Deformity managemernt: Single event multilevel surgery, like lengthening hamstring, iliopsoas,correction of bony problems like such as medial femoral tortion,lateral tibial torsion & stabilization of foot.

Orthotic management: long term use of ground reaction AFO until the integrity of the PF-KE couple is clearly established.


E

Ataxic Cerebral Palsy

1 in 20 children with CP have tremor and ataxia.

Ataxic cp gait is characterized by instability a wide base of support, difficulty performing smooth coordinated movements, & significant cycle to cycle variability. Walking is unsteady & there are fluctuation of muscle tone. Weakness or hypotonia of the trunk & limb girdle requires the child to use fixing patterns to gain stability. Many children with a primary diagnosis of diplegia,hemiplegia,or quadriplegia also have mild ataxia. Ataxic children cannot coordinate their movements. They are hypotonic during the first 2 years of life. Muscle tone becomes normal and ataxia becomes apparent toward the age of 2 to 3 years. Children who can walk have a wide-based gait and a mild intention tremor (dysmetria). Dexterity and fine motor control is poor. Ataxia is associated with cerebellar lesions.

Mixed Cerebral Palsy

(Spasticity, dystonia and ataxia)

Mixed Cerebral Palsy

Children with a mixed type of CP commonly have mild Spasticity, dystonia, and/or athetoid movements . Ataxia may be a component of the motor dysfunction in patients in this group. Ataxia and Spasticity often occur together. Spastic ataxic diplegia is a common mixed type that often is associated with hydrocephalus.

Abnormal planter flexion –knee extension couple

Children with CP often entire the the walking cycle with a foot flat initial contact which rapidly paeces the gastrocnemius under prekature tentionat both ends of the muscle. Gage (1991) postulates that in response to the stretch Spasticity can be elicited that can restrict tibial advancement, produce knee extention (hyperextention)& reduce the extent of dorsiflexion.The spastic response is revealed in a biphasic pattern during stance phase of increasing dorsiflexion & then decreasing dorsiflexion in the kinematics & by an abnormal planter flexion power generation co incident intimate with the first decrease of dorsiflexion in the cycle in the kinetics. The abnormal power generation elevates the body's center of mass & functionally increases energy expenditure.

ABNORMAL PLANTER FLEXION – KNEE EXTENTION COUPLE

Preventing plantar flexion has been shown to improve stability in stance phase ***(Miller and Chambers 1998–1999),*** clearance in swing phase ***(Õunpuu et al. 1996)***, pre-positioning in terminal swing ***(Romskes and Brunner 2000),*** and increase step length and walking speed (***Abel et al. 1998***). There is a suggestion that preventing plantarflexion also improves energy expenditure based on oxygen consumption ***(Maltais et al. 2001).*** There is no evidence to support any tone reducing effect on gait from orthoses that incorporate specially moulded footplates ***(Crenshaw et al. 2000).***

CORONAL & TRANSVERSE PLANE

Majority of children with spastic diplegia have the coronal plane & the transverse plane problems. In coronal plane,Spasticity or contracture of hip adductors may be evident, as well as such issues as limb length discrepancy & hip subluxation.The transverse plane the common problems are pelvic rotation ,medial femoral tortion,lateral tibial tortion & foot deformity.


E

EXCESSIVE HIP ADDUCTION

Causes:

The causes of excessive adduction of hip during the stance phase are-

- Adductor muscle Spasticity or contracture & unilateral adductor muscle weakness.
- Contra lateral hip adductor muscle contracture & scoliosis with pelvic obliquity.

The consequences of this deviation in stance phase are a decreased base of support in coronal plane & diminished limb stability.

Excessive adduction of hip is seen as a primary deviation in swing phase caused by-

- Adductor ms Spasticity or contracture.
- Limb length in equality.

The scissor gait deviation, seen in children with cerebral palsy, may appear to be due to excessive hip adduction on swing phase.

EXCESSIVE HIP ABDUCTION

Causes:

In stance phase –

1)Abductor contracture.

2)Limb length inequality in which ipsilateral limb is significantly short & scoliosis with pelvic obliquity.

In swing phase-

1)Ipsilateral abductor muscle contracture, Compensatory excessive hip abduction in swing is seen as a substitution pattern for weak hip flexor. This deviation is also combined with increased pelvic rotation & upward pelvic obliquity, as a means of clear a relatively long limb. Inadequate knee flexion & ankle dorsiflexion,CIRCUMDUCTION GAIT)


C
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INTERNAL FEMORAL TORTION(Femoral antevertion)

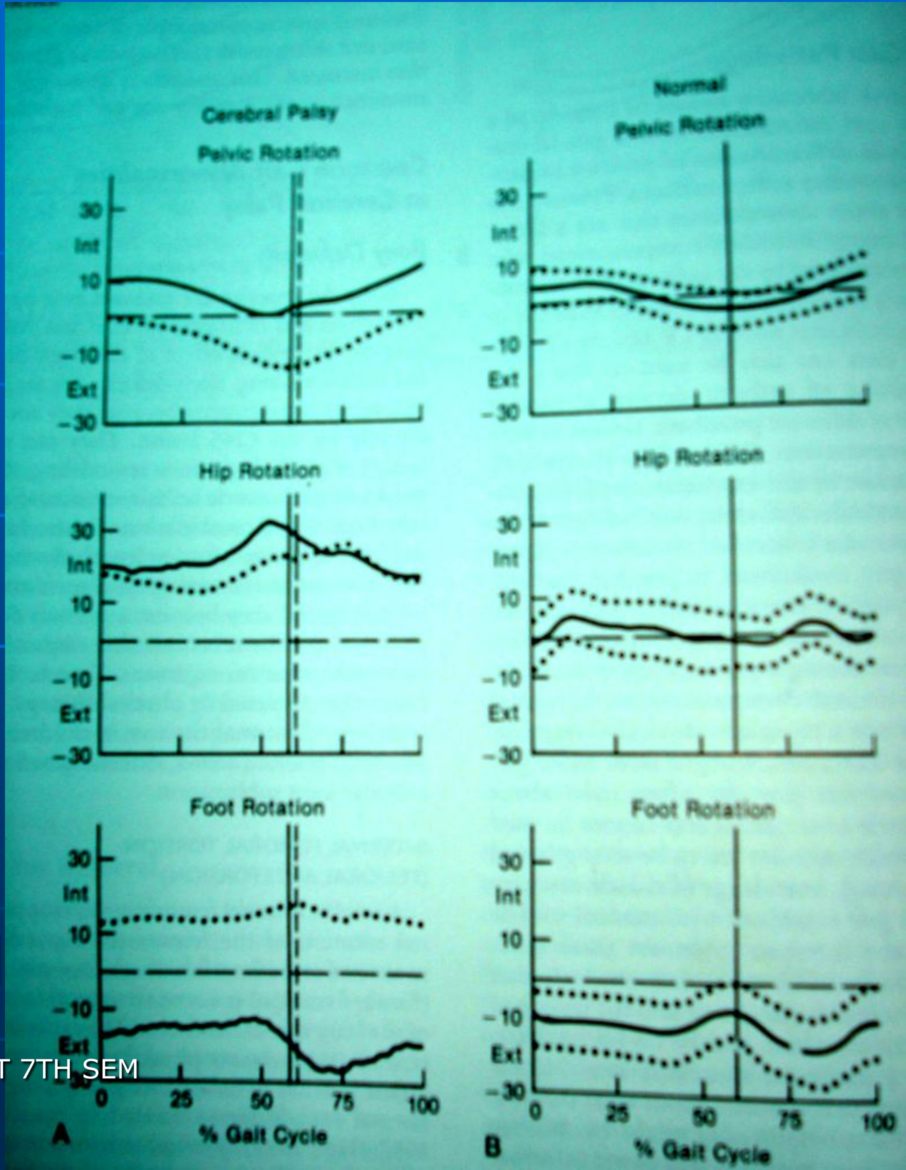
Identification:

Antevertion can be clinically measured as the degree of internal femoral rotation in the prone position required to position to greater trochanter most lateral or parallel to the supporting surface.*(Ryder & crane 1953).*

Usually in the presence of internal femoral tortion there is loss of passive external rot range & the inter rot range is excessive .

INTERNAL FEMORAL TORTION(Femoral antevertion)

In the figure the kinematic graph A is taken from a 10 yrs old child with sp diplegia CP compared with (B) normative data for pelvic & foot rotation & foot progression The hip rotation in child shows bilateral intr rotation .The foot rotation graph displays an appropriate external foot progression on the right despite internal hip rot on rt side. This could result from either subtalar joint subluxation or external tibial tortion,or a combination of both.



ORTHOTIC MANAGEMENT

Hip abduction orthoses for ambulant children may therefore be of little benefit.

EXTERNAL TIBIAL TORTION

It is an external rotation or tortion of the long axis of tibia. It is measured most appropriately by physical examination of the transmalleolar axis or thigh foot axis ,not by gait analysis. External tibial tortion is a true bony deformity that often develops as a secondary impairment to internal femoral tosion.Limited knee motion that results in repetitive dragging of foot in an external rotated posture for clearance can also results in the deformity. The internal tortion of femur is compensated by external tortion of the tibia so that the foot remains in the direction of progression.

The angle of the feet relative to the thigh (the thigh-foot angle) shows the degree of external tibial tortion


J
K

PES VALGUS

It is most common in the children with sp .diplegic. or spastic quadriplegics less after spastic hemiplegics.

Cause –Subluxation of talus on the os calcis .,it usually develops because of muscle imbalance & a combination of tightness & weakness.Visualy the calcaneus is in positioned in evertion.The effect of the deformity is measured in planter flexion-dorsiflexion & foot rotation graphs. Gastrocnemius Spasticity is another cause of pes valgus.


A

HIP ABDUCTOR WEAKNESS

Uncontrolled pelvic drop in the swing side & lateral trunk shift over the stance limb are seen in cp for this reason. Ground reaction force in coronal plane produces an external adduction moment at the all joints in the stance limb. If abductor strength is insufficient the lateral trunk shift positions the ground reaction force through the hip joint centre so no abductor moment is needed. Hip abductor ms weakness is frequently seen in children with femoral antetortion because tortion creates in adequate lever arm on which gluteus medius acts imposing functional weakness.On kinetic graph hip abductor weakness is displayed by increased adduction.

Management : The only remedy for trunk lurch is using a mobility device such as a walker or canes. Strengthening the hip abductors may also be helpful.

Table II: Algorithm used to classify children with cerebral palsy by Gross Motor Function Classification System (GMFCS)

Description taken from Evans form[19]	*Computed GMFCS level*
Leg function equal to 'no significant problem with gait, walks fluently' and 'aids used regularly to facilitate walking' equal to 'no'	Level I
Leg function equal to 'gait functional but non-fluent' and 'aids used regularly to facilitate walking' equal to 'no' OR Leg function equal to 'gait obviously abnormal reducing mobility and/or restricting lifestyle' and 'aids used regularly to facilitate walking' equal to 'no'	Level II
Leg function equal to 'gait functional but non-fluent' and 'aids used regularly to facilitate walking' equal to 'yes' OR Leg function equal to 'gait obviously abnormal reducing mobility and/or restricting lifestyle' and 'aids used regularly to facilitate walking' equal to 'yes'	Level III
Leg function equal to 'gait obviously abnormal reducing mobility and/or restricting lifestyle' and 'aids used regularly to facilitate walking' equal to 'yes' AND Trunk control equal to 'can sit unsupported but less secure and stable than normal child of same age' OR Arm function equal to or worse than 'physically incapable of putting on vest or T-shirt without help but able to feed self with one or other hand'	Level IV
Leg function equal to 'no independent walking' with or without the use of aids AND Trunk control equal or worse than 'cannot be left in sitting position unless supported'	Level V (not tested here)

MANAGEMENT

Children in GMFCS levels I–III, and to some extent those in level IV, should be encouraged to achieve an optimally efficient gait. Gage listed the prerequisites of normal gait first proposed by Perry ***(Gage 2004).*** Lower-limb orthoses may improve gait efficiency by restoring these prerequisites through altering the forces acting on the body. Orthoses may also reduce energy expenditure further by decreasing the need for compensatory gait deviations to achieve locomotion.

GMFCS levels I and II

As children with hemiplegia are predominantly classified in GMFCS levels I and II, they are by definition walking without mobility aids and perform most activities albeit slower and with qualitative differences. Provision of PLS or solid AFOs to prevent plantarflexion occasionally impede some tasks and the wearing regimen can be modified not to interfere with these activities; for instance the AFO might not usually be worn while participating in sports unless it improved the child's performance.

GMFCS Level III

Those in Level III are dependent on using assistive mobility aids. Recommendations for orthotic intervention to improve gait efficiency are based on the integrity of the plantar flexion –knee extension couple. This describes the normal relationship between the ankle–foot complex and the knee joint to maintain the ground reaction force (GRF) just in front of the knee during stance phase. The foot must be leading approximately in the line of gait progression and the Gastrocnemius and soleus muscles functioning eccentrically to control tibial advancement ***(Gage 2004).***

GMFCS levels IV and V

Children in GMFCS levels IV and V might be classified as having spastic diplegia or quadriplegia and are more severely limited in their activities. AFOs are used to limit equinus deformity and to provide a stable base and encourage weight-bearing during standing transfers. Maintaining reasonable foot and ankle posture will enable more comfortable posture in seating systems by allowing some of the weight of the lower limbs to be supported by footplates. If profound fixed ankle and foot deformities become established then fitting of ordinary shoes can become a problem and custom-made footwear or surgical treatment may be required.

GMFCS levels IV and V

Children at level V spend all their time in either lying or sitting postures. They are therefore dependent on the provision of appropriate seating and lying postural management systems for comfort and optimal functioning.

Functional Outcome

- Assessment and documentation of outcomes related to physical function in patients with ambulatory CP
- Pediatric Outcomes Data Collection Instrument (PODCI) Parent and Child versions.

- Gillette Functional Assessment Questionnaire (FAQ) Walking subscale.

- The Gross Motor Function Measure (GMFM) Dimensions E.

- The WeeFIM Self-Care and Mobility subscales also related well to other measures of physical functioning.

- When available, temporal–spatial parameters and O2 cost are important indicators of physical function and are useful in the assessment of outcomes.

ANKLE FOOT ORTHOSIS

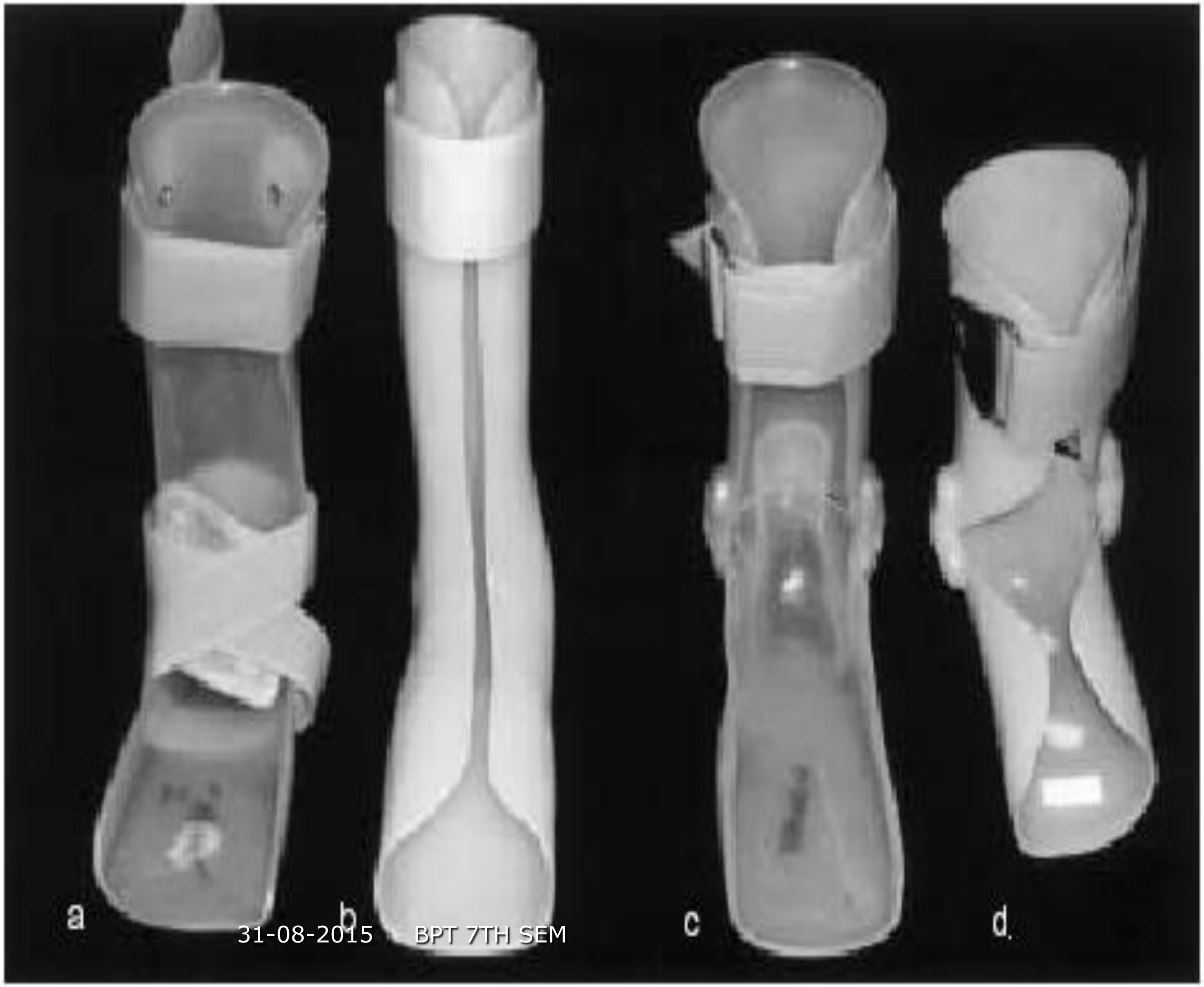


Figure 1: *(a) Solid ankle foot orthosis; (b) anterior/dorsum trim solid ankle foot orthosis; (c) hinged ankle foot orthosis; (d) anterior/dorsum trim hinged ankle foot orthosis.*

LOWER LIMB ORTHOSIS

The aims of lower-limb orthotic management of CP were identified by a consensus conference convened by the

International Society of Prosthetics and Orthotics (ISPO) as

(1) to correct and / or prevent deformity,
(2) to provide a base of support.
(3) to facilitate training in skills.
(4) to improve the efficiency of gait .
(Condie and Meadows 1995).

Orthoses increases in velocity of gait in children with cerebral palsy

- AFOs are typically prescribed to prevent deformity, support normal joint alignment and mechanics, provide variable range of motion when appropriate, and facilitate function. When wearing AFOs, statistically significant increases in stride length, step length, and velocity were noted. This retrospective review demonstrates that AFOs in our population provide clinical improvements in the temporal and spatial parameters of gait. As velocity is the product of stride length and cadence, the increase in stride length but not cadence resulted in an increase in velocity for this CP population. *Hank White(2002)*

A systematic review of the effects of casting on equinus in children with cerebral palsy

The decision about the use of casting for equinus in children with CP is a complex one owing to differences in protocols.

There is little evidence that casting is superior to no casting (with significant improvements only in stride length)- ***Bertoti-D.B(1986)***

The protocols of casting in current use have not been compared with no treatment in any RCT. There is no strong and consistent evidence that combining casting and BTX-A is superior to using either intervention alone: in fact there is some evidence that casting alone may be better at reducing Spasticity 6 to 12 month post treatment . *Kay R M(2004)*

Conti…..

There is no strong and consistent evidence that either casting alone or BTX-A alone is superior to the other immediately after treatment, though BTX-A may be slightly better after 12 weeks.***Corryls(1998)***

Finally, there is no evidence that order of treatment (casting before BTX-A versus BTX-A before casting) affects outcome. Therefore, there is currently no clear evidence that any of the three procedures – casting, BTX-A, or the combination – is superior to the others, and, therefore, treatment choices between them will depend upon other considerations, such as availability, cost, convenience, family preference, and therapists' experience with the treatments.

Functional Outcome

- Assessment and documentation of outcomes related to physical function in patients with ambulatory CP
- Pediatric Outcomes Data Collection Instrument (PODCI) Parent and Child versions.
- Gillette Functional Assessment Questionnaire (FAQ) Walking subscale.
- The Gross Motor Function Measure (GMFM) Dimensions E.
- The WeeFIM Self-Care and Mobility subscales also related well to other measures of physical functioning.
- When available, temporal–spatial parameters and O2 cost are important indicators of physical function and are useful in the assessment of outcomes.

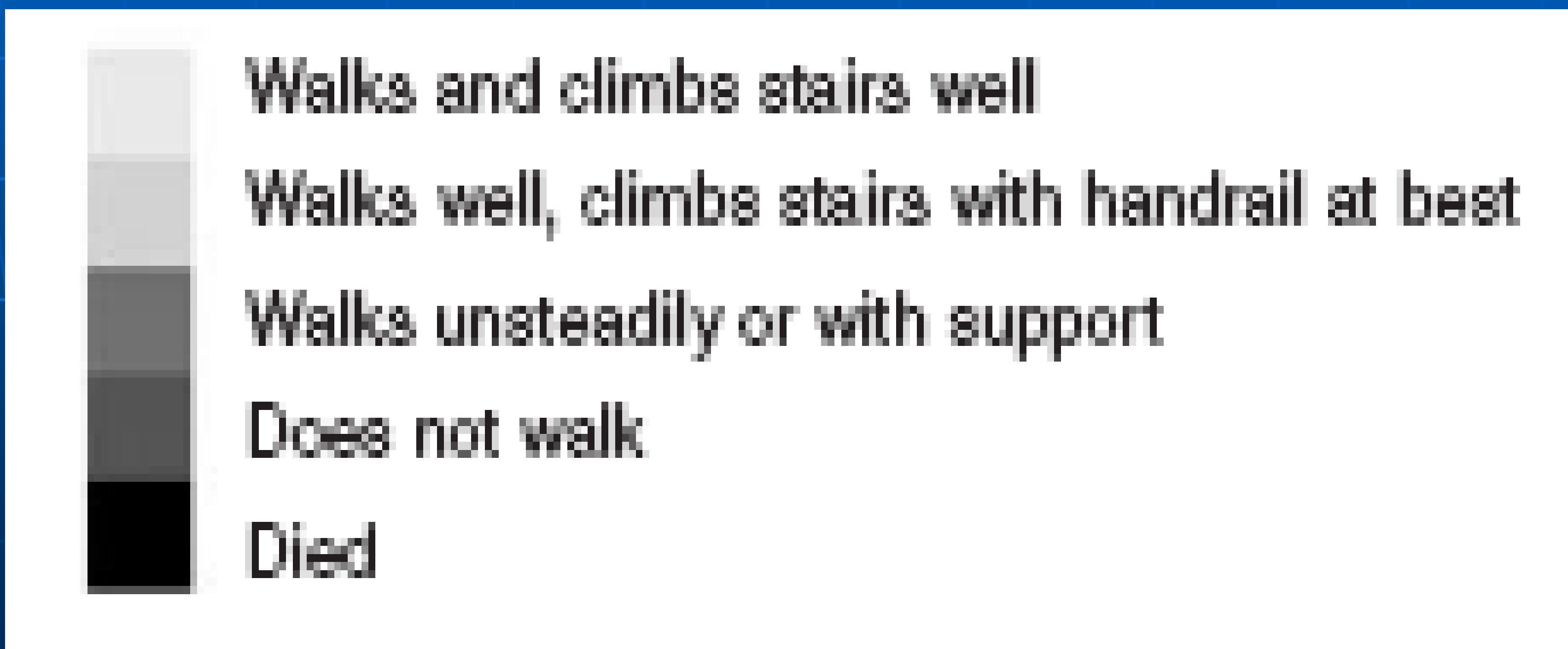
Robotic assisted locomotor training in children with central gait impairment

The DGO is a promising tool for use with children with central
gait impairment. It provides higher intensity gait therapy to help patients regain or improve walking capacity. This may be the principal advantage over conventional gait or treadmill training, which may have the same effect but requires more effort and more therapists. For children with CP this may include the potential to investigate whether specific and intensive gait training at an earlier age would affect achievement of walking capacity. (A Meyer –Heim 2007)

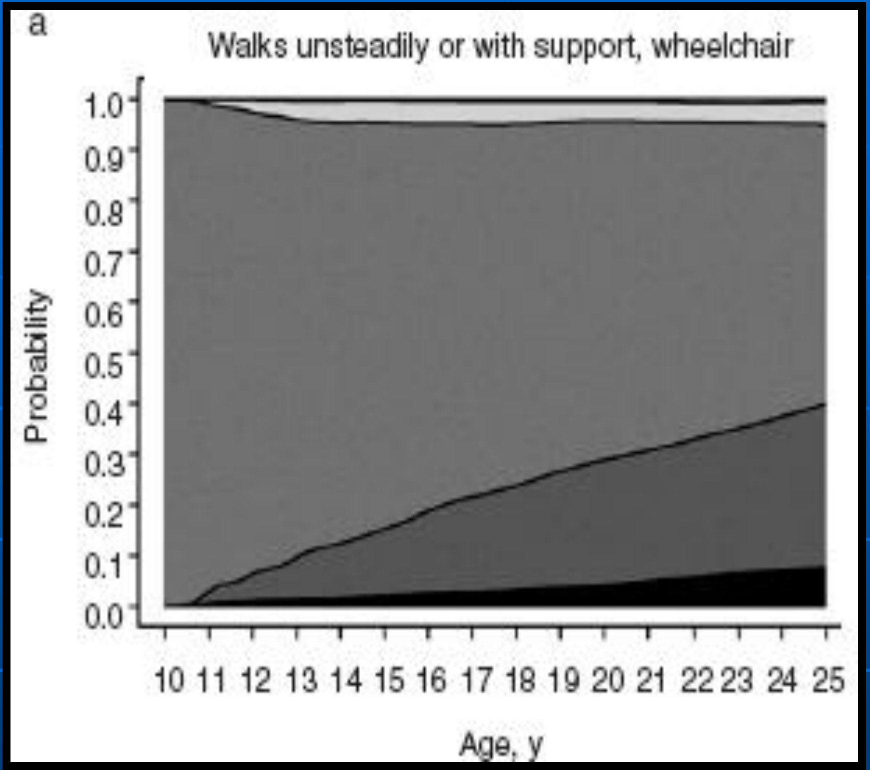
Effects of a static bicycling programme on the functional ability of young people with cerebral palsy who are non-ambulant

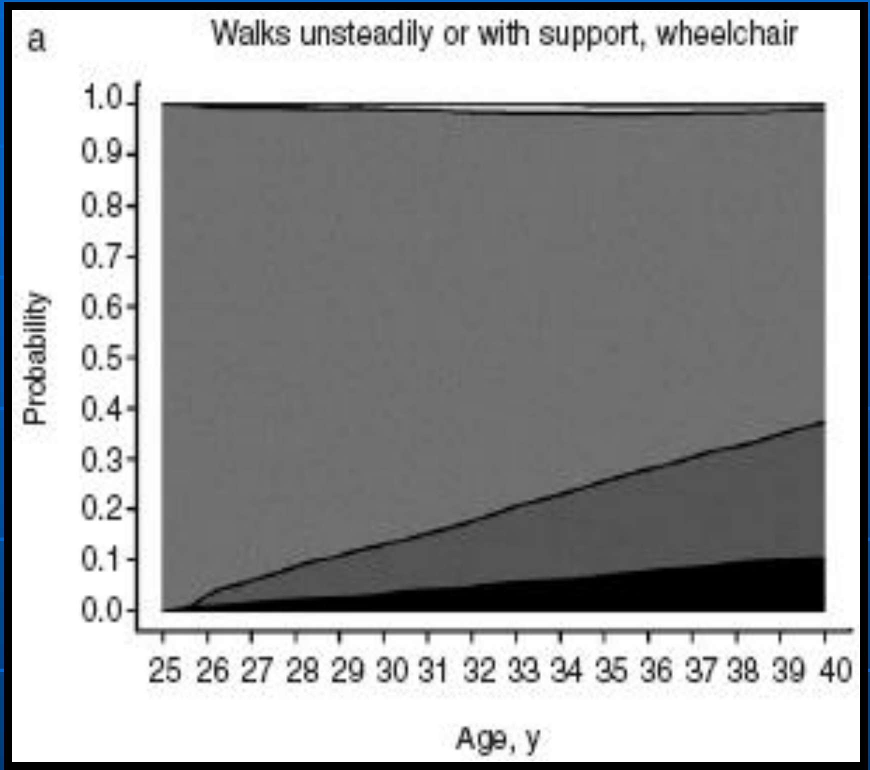
It is a relatively short training programme on a static exercise bicycle, adapted to provide additional postural support, associated with a clinically relevant improvement in standing and walking abilities of young people with severe levels of CP (GMFCS Levels IV and V) who are non-ambulant. It is a safe and effective treatment for young people with severe CP. (Heather Williams2007)

Change in ambulatory ability of adolescents and young adults with cerebral palsy



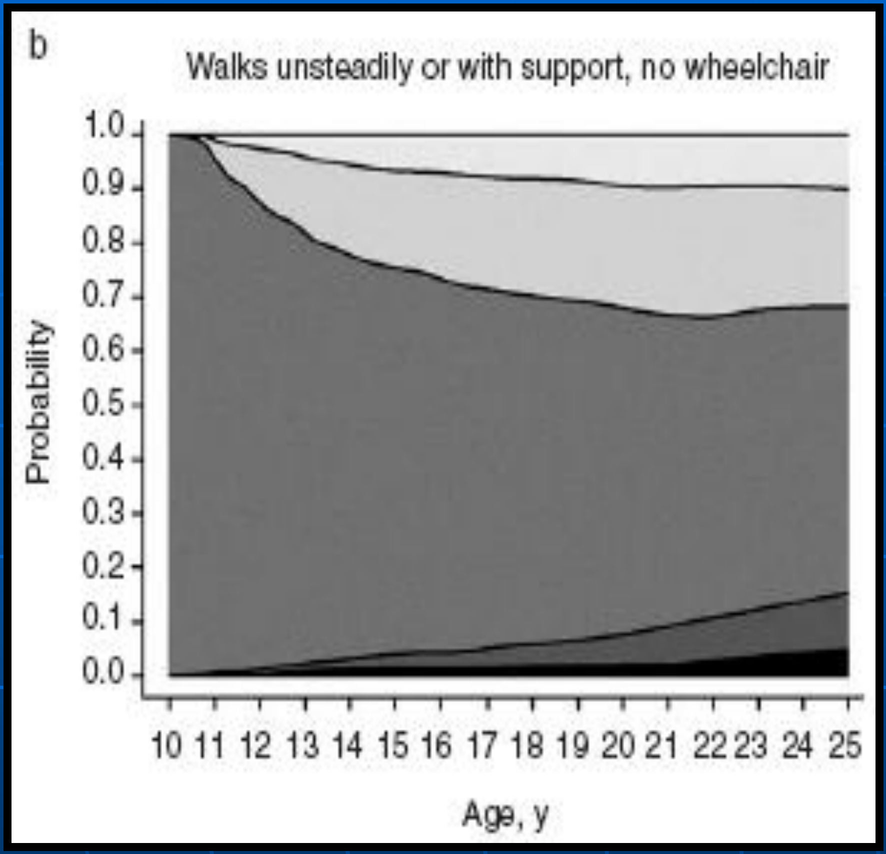
Change in ambulatory ability of adolescents and young adults with cerebral palsy

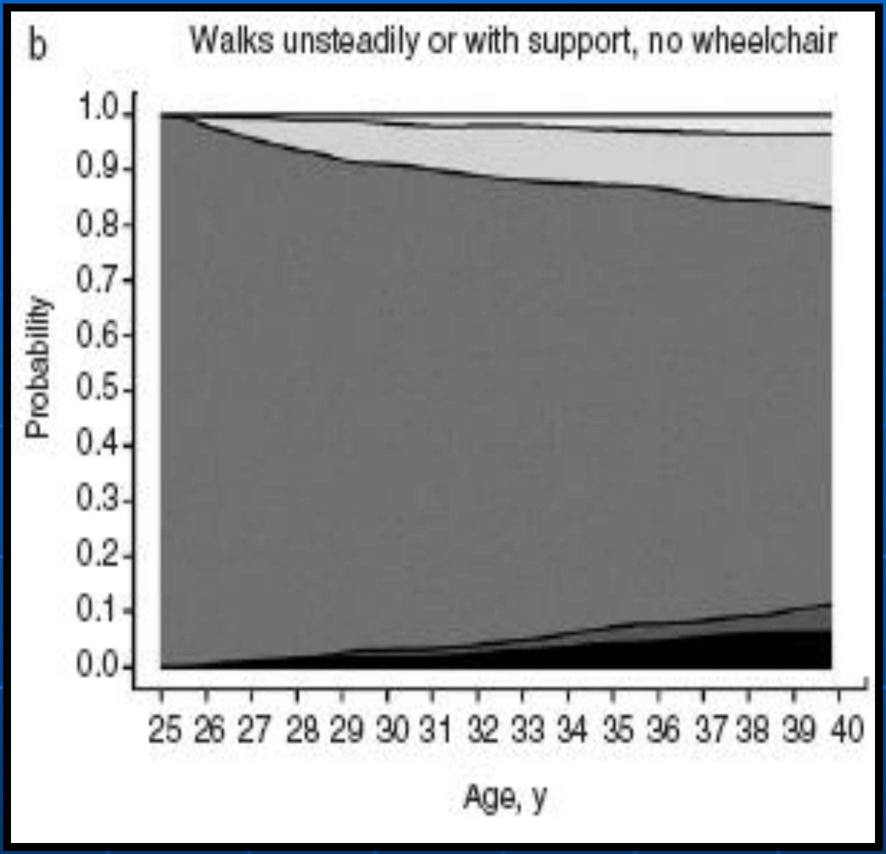




- *Subsequent walking ability for persons with cerebral palsy aged 10 years (LEFT)*
- *Subsequent walking ability for persons with cerebral palsy aged 25 years (right)*

Change in ambulatory ability of adolescents and young adults with cerebral palsy





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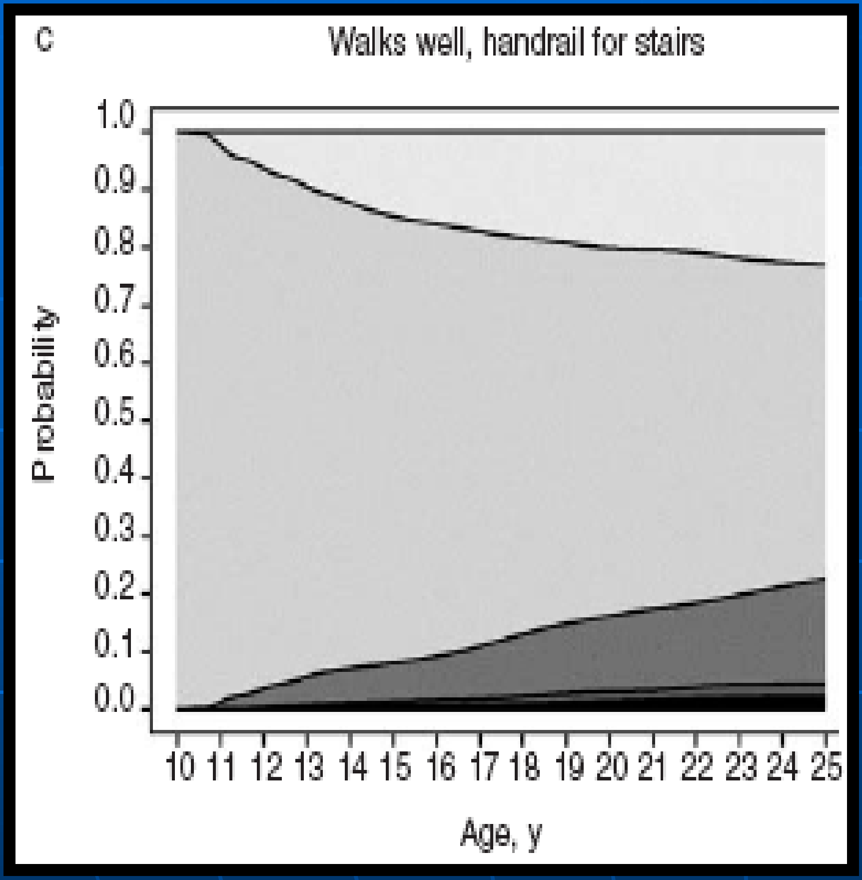

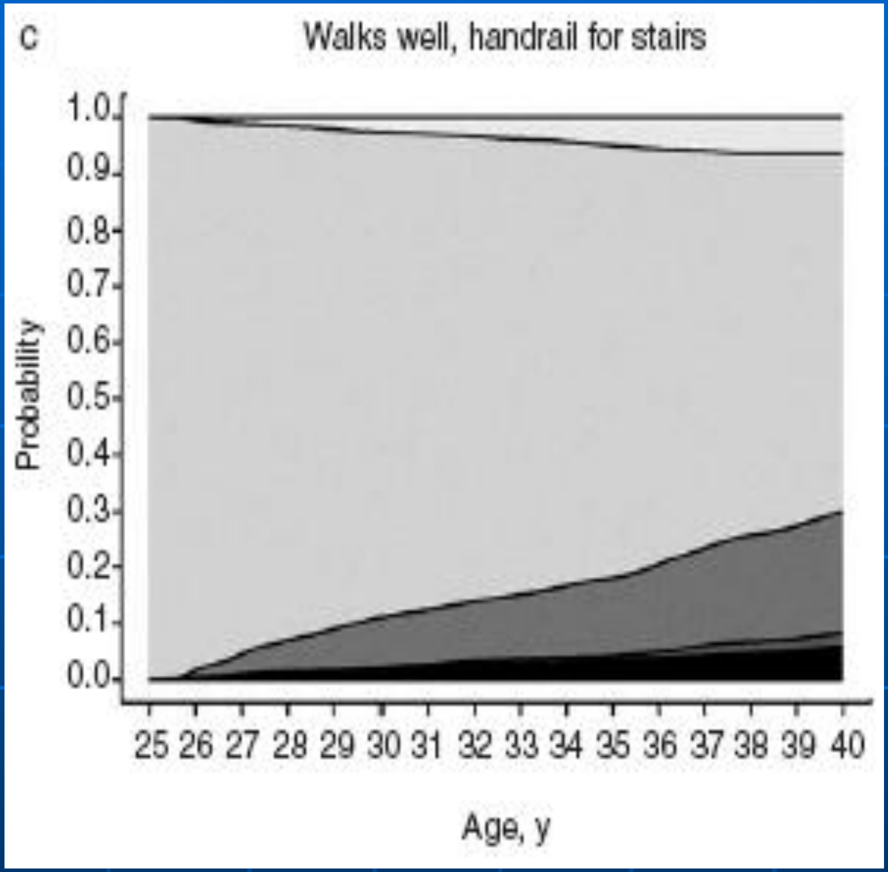

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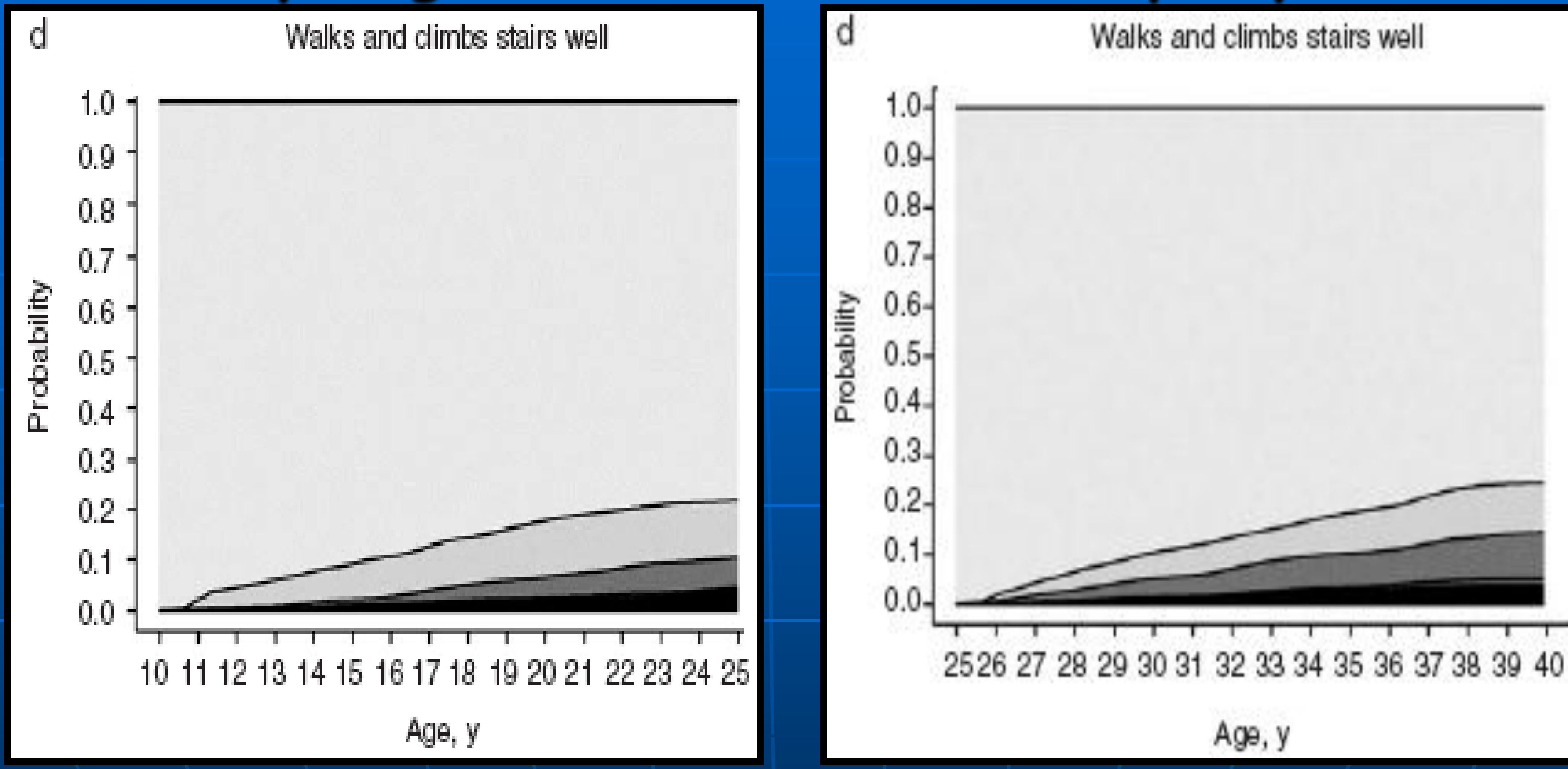

- *Subsequent walking ability for persons with cerebral palsy aged 10 years (LEFT)*
- *Subsequent walking ability for persons with cerebral palsy aged 25 years (right)*

Immediate effect of percutaneous intramuscular stimulation during gait in children with cerebral palsy

Margo N Orlin(2005)

- It shows that P-FES applied to the Tibialis Anterior and Gastrocnemius muscles together at appropriate times in the gait cycle is a feasible method of immediately improving ankle dorsiflexion in children with spastic diplegic or spastic hemiplegic CP. Trends also indicated that stimulation of the TA alone might also improve ankle dorsiflexion during gait. No temporal–spatial or kinetic characteristics of gait changed with stimulation, suggesting that these is difficult to modify, particularly with a short-term application of P-FES. Because this feasibility study used a short-term application of P-FES to produce only an immediate change.

Strength training in young people with cerebral palsy

- It supports the view that home-based strength-training programmes can improve muscle strength in young people with spastic diplegic CP. Trends also suggest that strength training may have beneficial effects on activities in walking, running, and jumping, as well as stair climbing. *(Karen J Dodd 2003)*
- This study show that a 10-week progressive strength training programme focused on the lower extremities improves walking ability. Results show significant improvements in muscle strength, walking velocity, and gross motor function in standing and walking in the training group, but no change in Spasticity was found. ***C Andersson(2003)***

Electrical stimulation of gluteus maximus in children with cerebral palsy

- Electrical stimulation of the gluteus maximus applied with the regime used in the present study did not result in any significant statistical or clinical improvement in hip extensor strength, gait characteristics, passive limits of hip rotation, or gross motor function.
  ML van der Linden(2003)

Electrical Stimulation In Cerebral Palsy

Muscles stimulated	*Outcome measures*	*Results*
Tibialis anterior, extensor digitorum	Strength, fatigue, motor function	↑ strength, ↓ fatigue, ↑ gait, ↑ motor performance
Quadriceps, tibialis anterior	Standardized gait testing	↓ use of assistive devices for ambulation
Tibialis anterior, triceps surae, ± medial hamstrings	PCI, pedogaphs, gait videos, active and passive ROM	↓ PCI, ↑ active and passive ROM, improved gait parameters
Triceps, anterior deltoid, elbow and wrist extensors, finger flexors and extensors, thumb abductors and extensors	Ability to creep, ability to use both hands together, functional use of UL (all obs), ROM, grasp and release	↑ passive ROM thumb and hand, ↑ active ROM wrist, improved awareness and spontaneous use of UL, ↓ neglect of UL, improved grasp and release and gross motor function
Gluteus maximus, triceps surae, ± tibialis anterior, lateral hamstrings, external obliques	Gait (obs), ROM, MMT, foot alignment, motor function	↑ ROM, ↑ leg strength, improved balance, leg function, posture, foot alignment, motor function, ↓ falls and improved gait parameters
Finger flexors/extensors, wrist extensors	Strength, Mowery's functional hand classification	Improved hand function, ↑ shoulder strength
Erector spinae, gluteus maximus, rectus femoris, oblique abdominals, vastus lateralis, vastus medialis, tibialis anterior, gastrocnemius	Function, posture, gait (descriptive), MMT, ROM, walking speed and distance	↑ tibialis anterior muscle strength, ↑ ROM, ↑ distance ambulated, ↑ ADL function and improved gait parameters
Gluteus medius, gluteus maximus, vastus lateralis, vastus medialus, gastrocnemius, tibialis anterior	Gait analysis with pedograph paper, ROM, gross motor function	Improved gait parameters and gross motor performance, ↑ ROM


THANK YOU