
بسم الله الرحمن الرحيم

Spasticity Management in Children with Cerebral Palsy

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Cerebral palsy

- CP is caused by abnormal brain development or non-progressive damage to the developing brain early in life

- Alterations in sensation, cognition, perception,communication, and behavior accompany the motor disorders seen in CP

- prevalence estimates CP to be from 1.5 to more than 4 per 1,000 live births

Cerebral palsy

- The etiology of CP may be due to prenatal (most cases), perinatal, or postnatal causes
- There are four main types of CP: spastic, dyskinetic, ataxic, and mixed
- Spasticity is the most common muscle abnormality and is a form of hypertonia that is characterized by a velocity-dependent resistance to muscle stretch

Hypertonicity

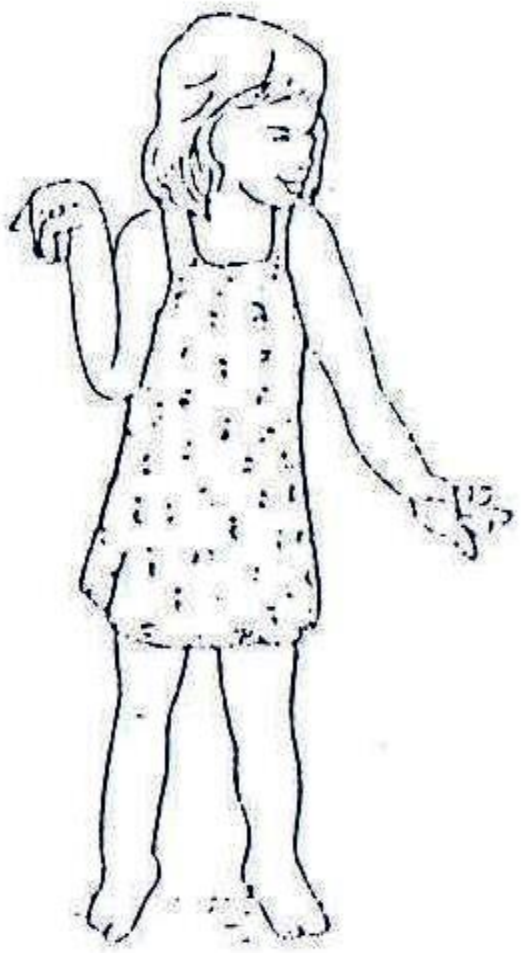
- Spasticity
- Rigidity
- Dystonia

WHAT IS SPASTICITY?

- Neuromuscular overactivity resulting in extreme involuntary muscle contraction
- Abnormal increase in tone accompanied by resistance to active and passive movement
- Positive sign of CNS pathology
  - UMN damage
  - Interruption or interference within the descending motor pathways
- Velocity dependent
- Extent and location of the damage/lesion can impact the type and level of impairment

Non-neural component of UMN symptoms

- Altered muscle length (elasticity): muscle fibers shorten (hypoextensible).
- Altered muscle structure (viscosity): filaments become sticky affecting muscle glide(stiffness).
- Abnormal co- contraction (reciprocal innervation) : due to bio-mechanical effects of abnormal position. (too much stability & not enough mobility).
- Changes in visco-elastic properties leads to stiffness, tightness & contracture



Neural components of UMN symptoms

Positive symptoms

- Spasticity.
- Spasms (flexor & extensor).
- Exaggerated tendon reflexes.
- Clonus.
- Babinski response.

Negative symptoms

- Weakness.
- Loss of dexterity.
- Fatigability.

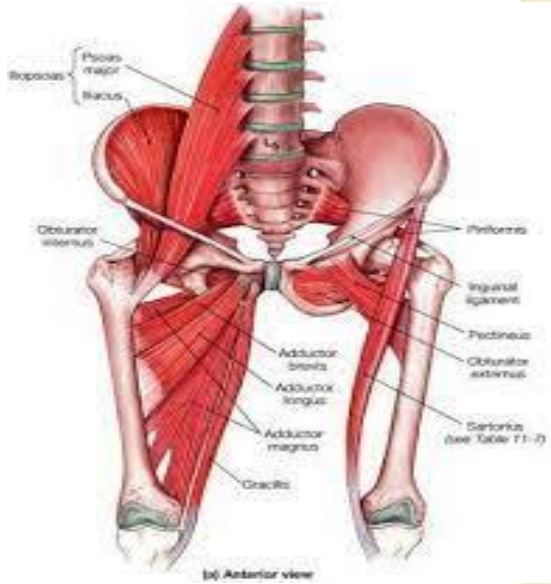
BIOMECHANICAL CHANGES

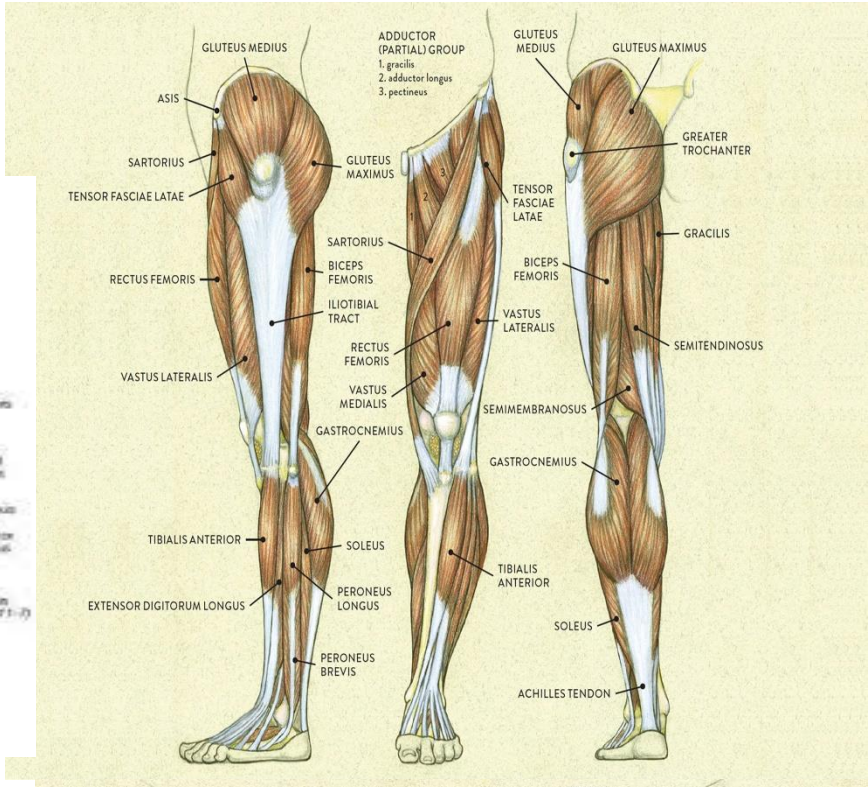
- Disuse atrophy
- Shortening of soft tissue (contractures)
- Maladaptive movements
- Abnormal posture

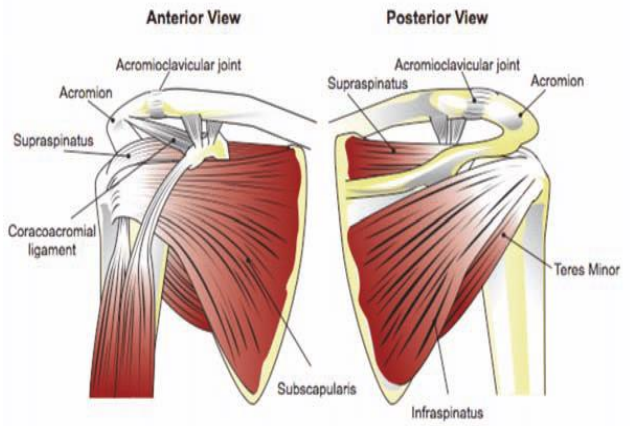
- What can this lead to?
  - Pain
  - Loss of range of motion
  - Skin breakdown
  - Fractures

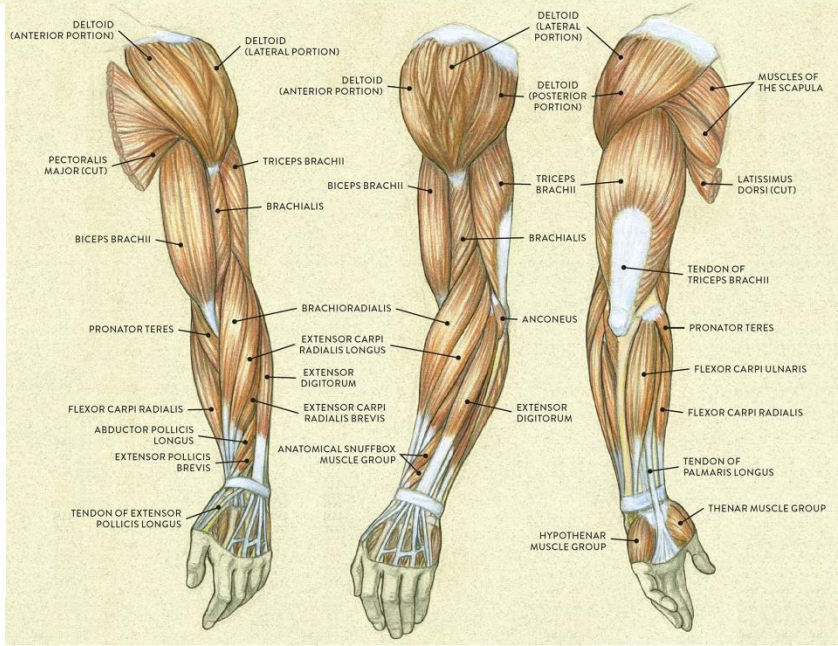
Spasticity Distribution in CP

- Lower extremities
  - Foot/Ankle region
    - **Equinus, Equinovarus, Equinovalgus**
  - Knee region
    - Flexion, Extension
  - Hip/Pelvic region
    - Int rot, Adduction, Flexion/Extension
- Upper extremities
  - Wrist/Hand region
    - Flexion/Extension
  - Elbow/forearm region
    - Flexion, Pronation
  - Shoulder/scapula region
    - Int Rot, Adduction



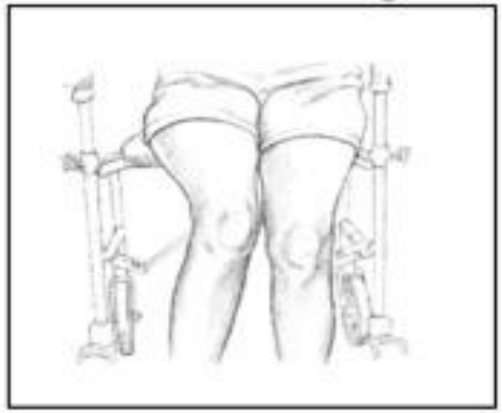






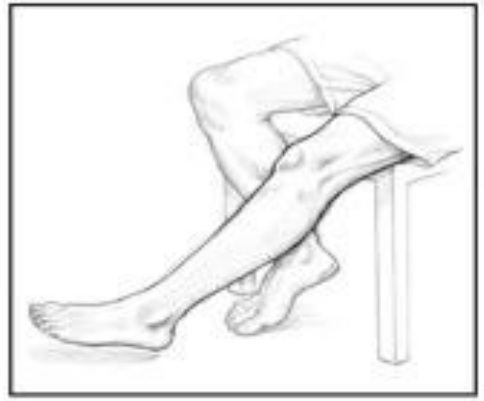
Lower Extremity Spasticity Patterns

Adducted Thigh

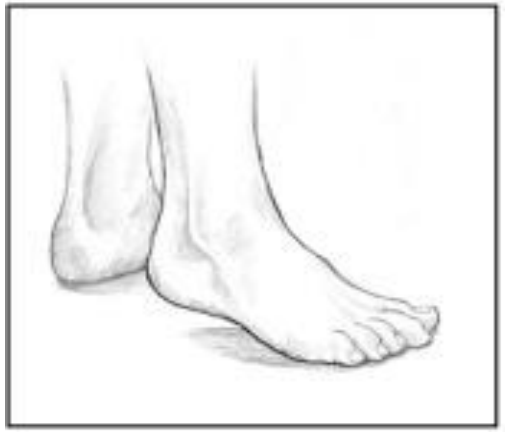


Flexed Knee

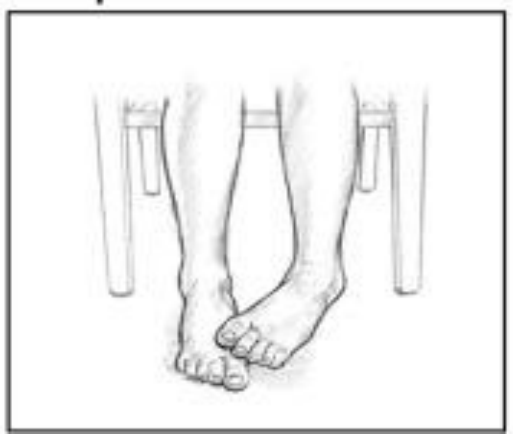
Extended Knee



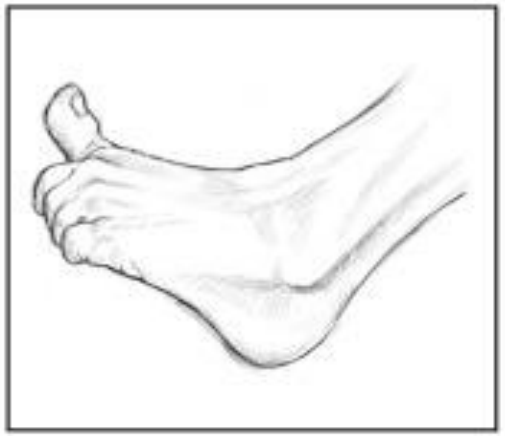
Plantar Flexed Foot/ Ankle



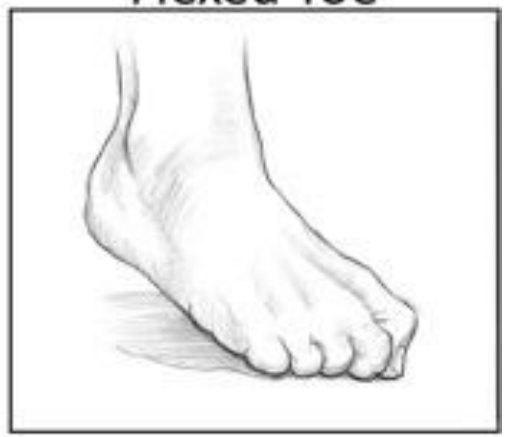
Equinovarus Foot



Striatal Toe



Flexed Toe



Tone assessment

- MODIFIED TARDIEV SCALE (Resistance to fast passive stretch) GRADE:

1- Slight resistance throughout passive movement with no clear "catch" at any specific angle.

2- Passive movement is interrupted at a specific angle by a clear "catch" followed by release.

3- Fatigable clonus(less than 10 sec) when maintaining the pressure, appearing at a specific angle.

4 -Indefatigable clonus(more than 10 sec) when maintaining the pressure, appearing at a specific angle.

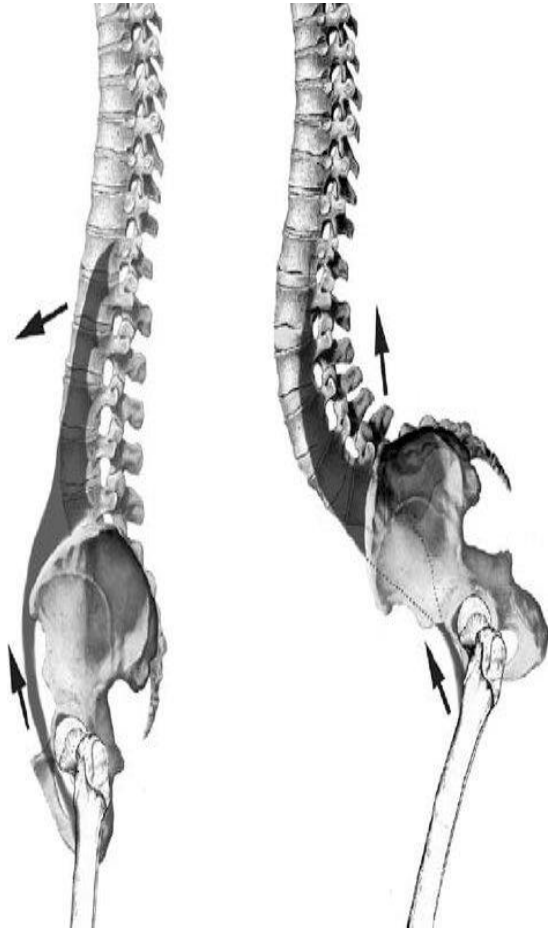
5- Joint is rigid.

MODIFIED ASHWORTH SCALE

GRADE	DESCRIPTION
0	No increase in muscle tone
1	Slight increase in muscle tone, evident as "catch" and release, or as minimal resistance at the end of the ROM when the examined joint is flexed or extended
1+	Slight increase in muscle tone, evident as "catch" followed by minimal resistance throughout the remainder (less than half) range of motion.
2	More marked increase in muscle tone through most of ROM but joint is still easily moved.
3	Considerable increase in muscle tone, passive movement is difficult.
4	Joint is rigid in flexion or extension.

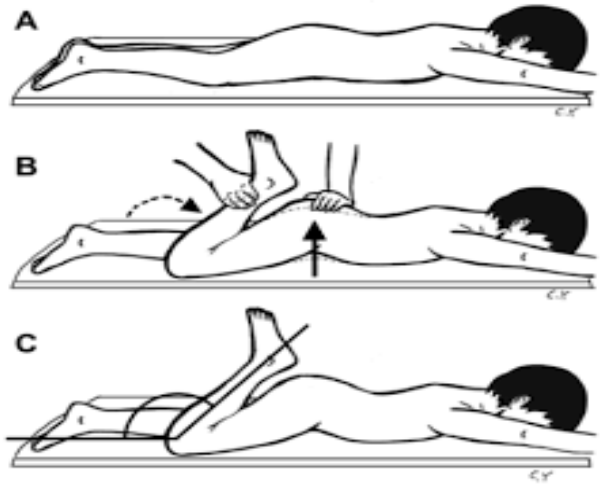
Hip flexion contracture

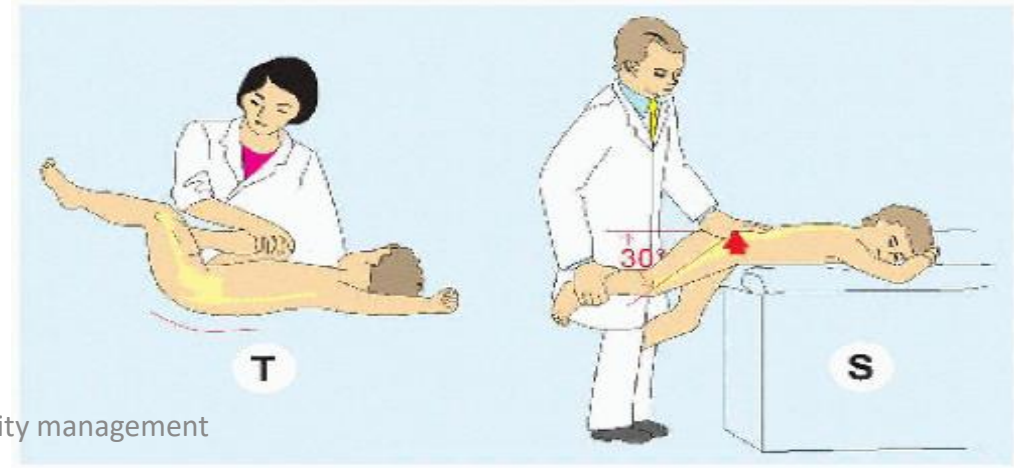
- Second most common hip deformities in CP patients are flexion contractures that bring the body's center of gravity anteriorly
- Hip flexion contractures are more common in patients with diplegia and quadriplegia, they are relatively rare in hemiplegic patients.
- Psoas muscle is the primary reason for the hip flexion contracture and is known to be associated with increased anterior pelvic tilt, crouch gait, hip instability and increased lumbar lordosis.



Hip Flexion contracture tests

- To assess the presence of the contracture, a clinical examination using the Thomas, Staheli and Ely tests is required.
- Thomas test is performed, keeping the patient in the supine position; to correct the lumbar lordosis and fix the pelvis, and the other hip and knee are put in full flexion. The angle between the femur of the tested side and the examination table indicates the grade of the hip flexion contracture.
- In the Staheli test, the patient lies in the prone position and the hip is left outside the examination table. The hip of the examined side is put in passive extension until pelvis extension is observed.
- Ely test is applied at prone position. One hip is stabilized manually and ipsilateral leg moved into flexion position by bending the knee. If the hip elevates from examination table that means rectus femoris is spastic.

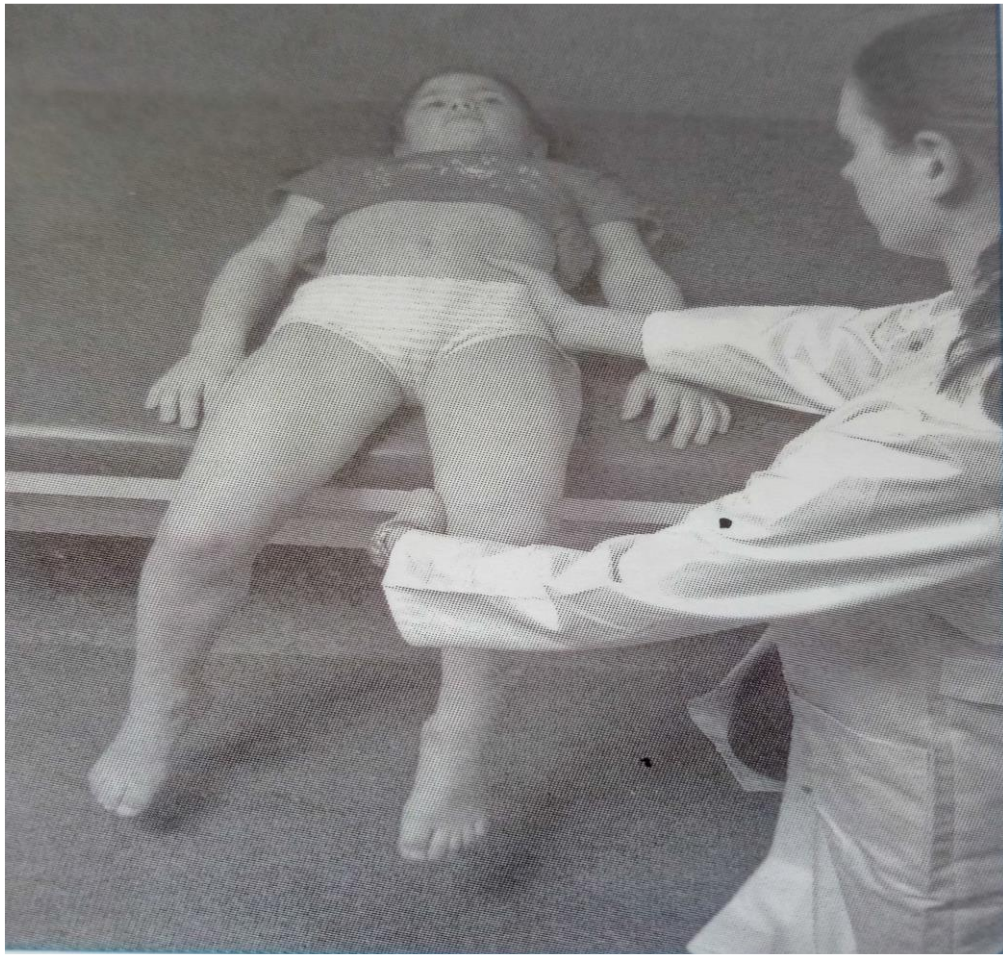




Hip adduction contracture

- Adduction contracture is most common hip deformity in CP patients. This hip problem cause hip subluxation, scissoring of the legs and perineal hygiene problems.

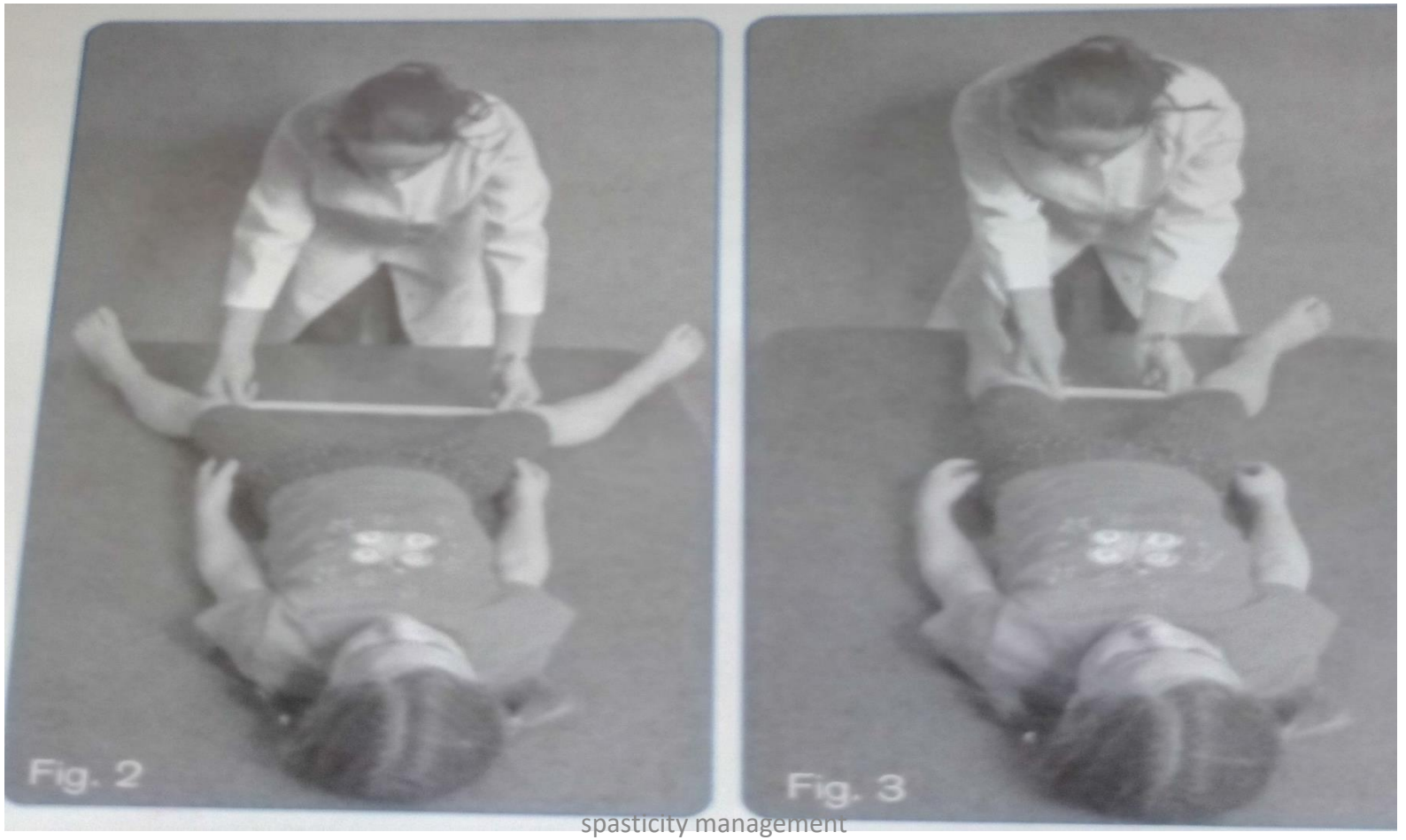
Gracilis test: the testing position is supine on table, hip extended in neutral position, lower legs hanging down from the table.



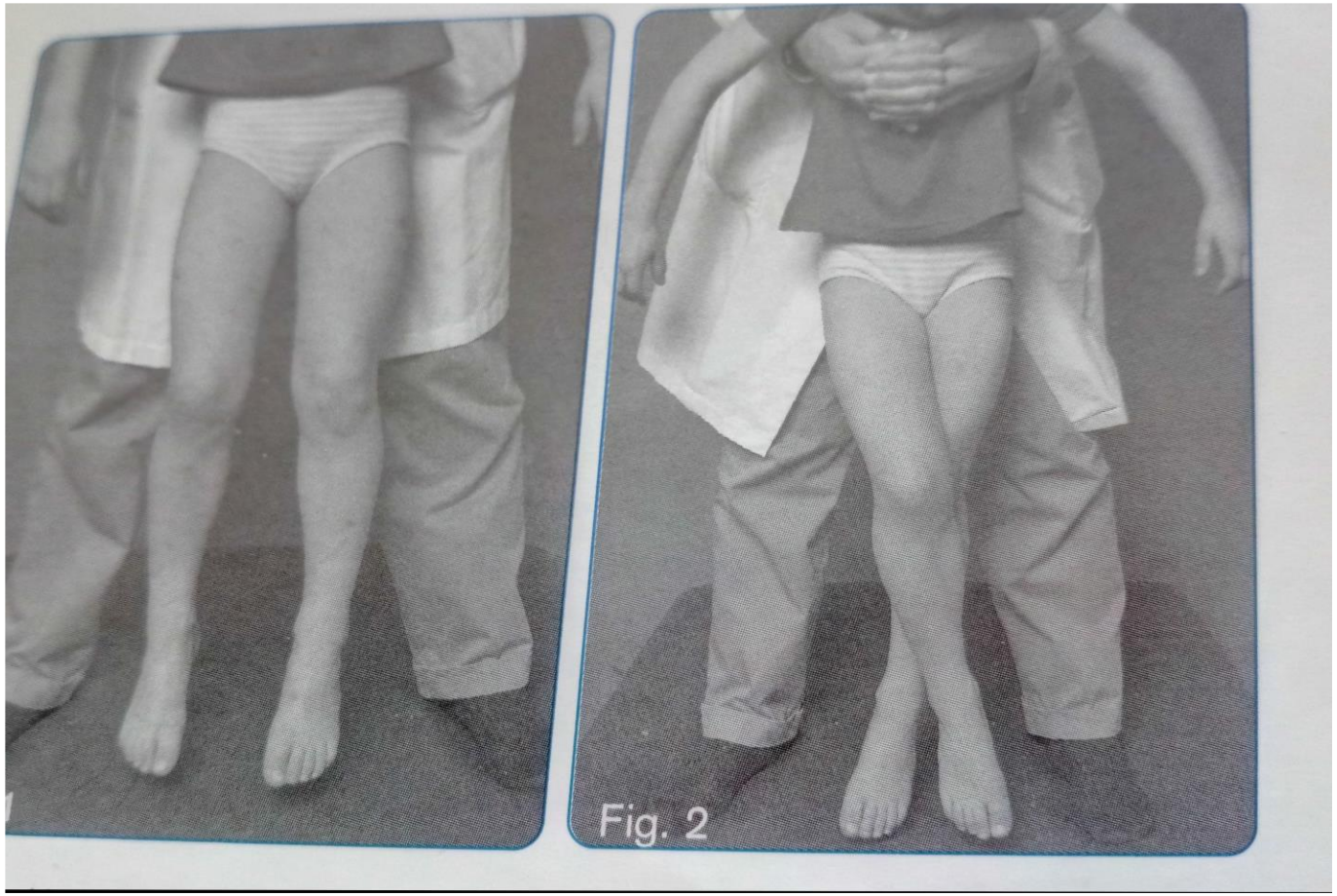
Phelps gracilis test

- **Prone position with the knee extended**
- **Passive abduction to the maximum with the extended knee**
- **Knees are then flexed 90 degrees to relax gracilis**
- **Attempt to further abduct the hip with knee in flexion**
- If **Further abduction is possible the test is positive for gracilis contracture**

Knee-distance test: Abduct both legs; measure the distance between the medial femoral condyles during maximal abduction in both slow and fast passive movements. The overall adductor spasticity is tested.



Pendulum test: the examiner lift the child off the ground and swing the child through between his legs. In Add spasticity, the child spontaneously adduct or cross the legs



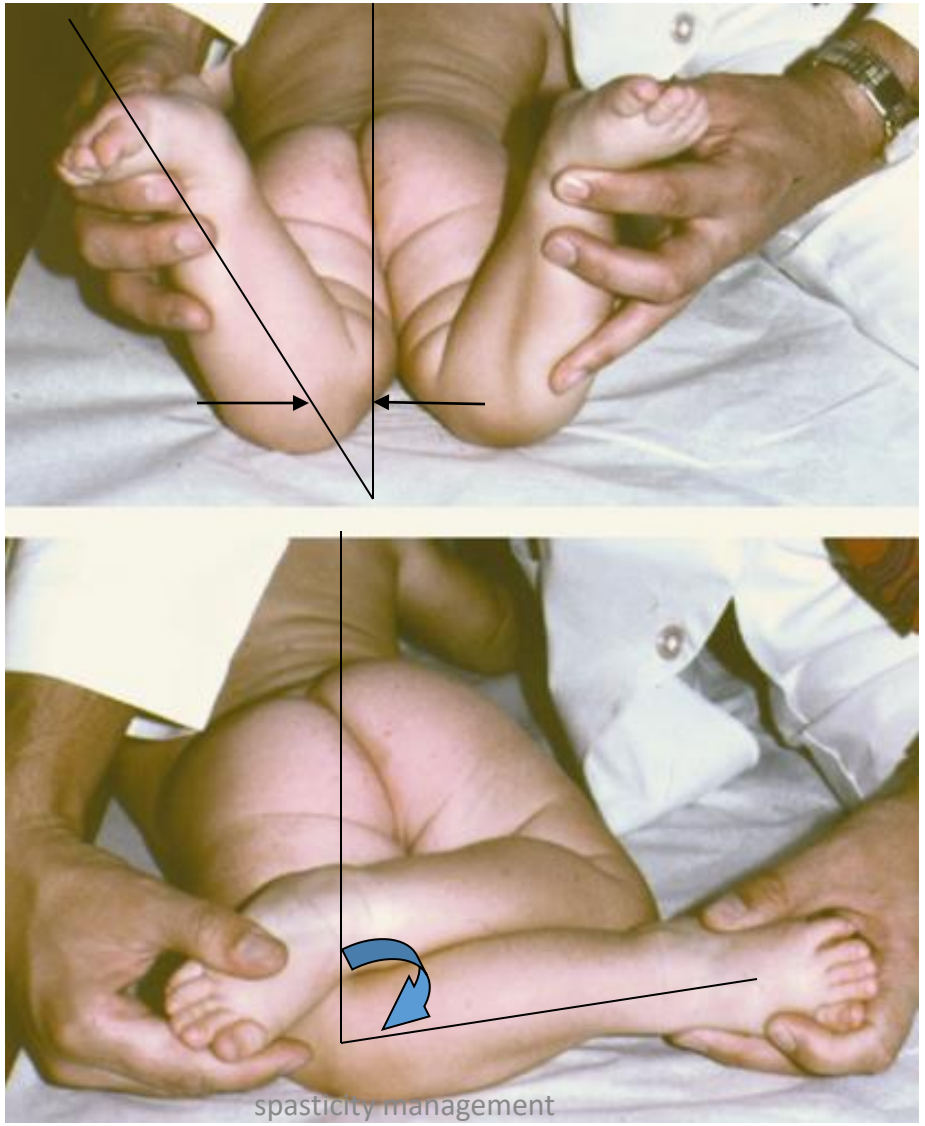
Internal Rotation Evaluation

- Determine foot progression angles
  - **Assess hip rotation**
  - Assess tibial rotation
  - Determine the alignment of the foot

Where is the source???

Assessing hip rotation

Medial Rotation Hip

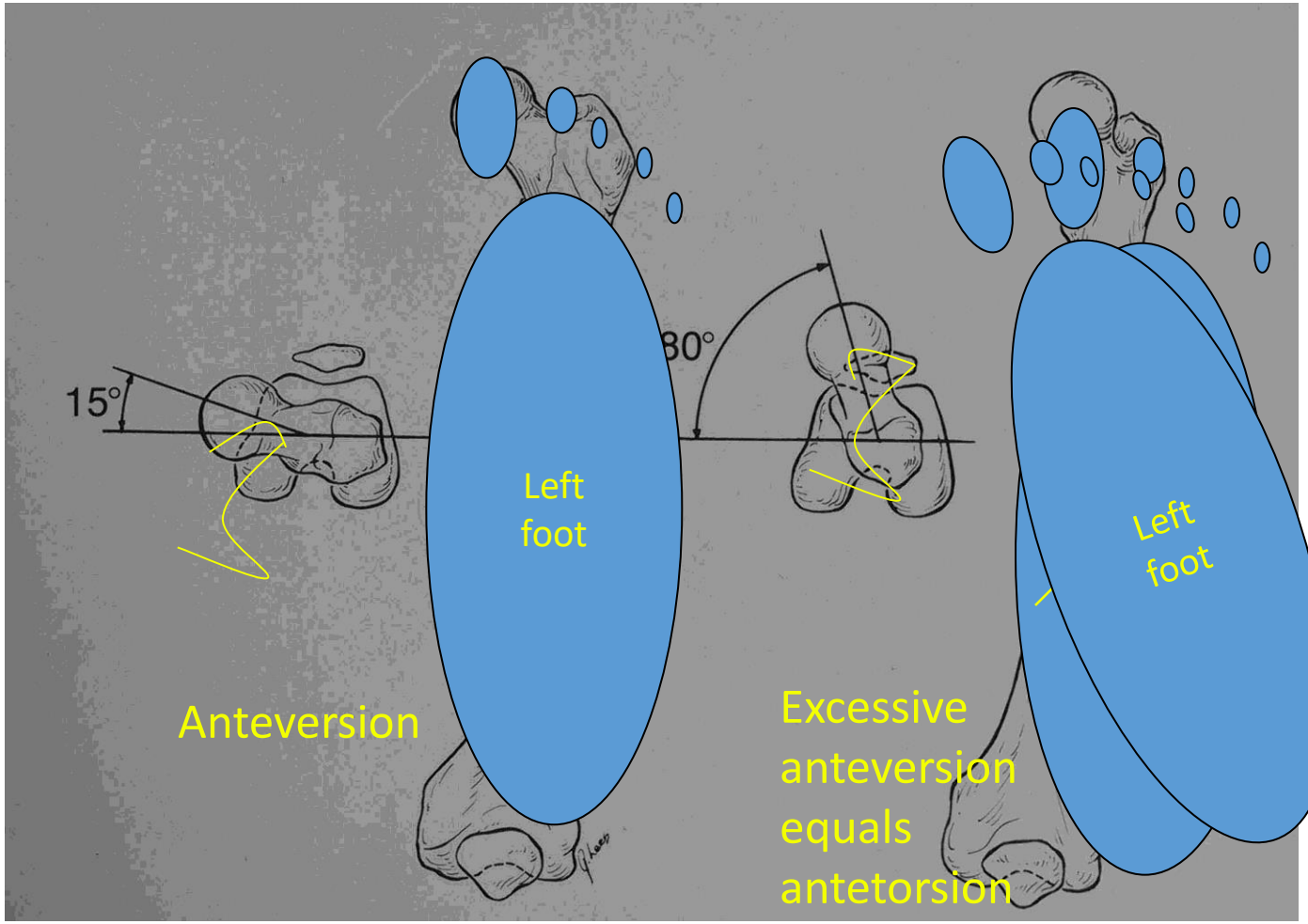


Lateral Rotation Hip

Causes of excess rotation

- **Soft tissues vs. bony anatomy**
- **Hip joint - soft tissue contractures**
  - **Newborns have an posterior capsular contracture, producing excessive lateral rotation of the hips**
- **Femoral antetorsion - bony anatomy**
  - **produces excessive medial rotation at the hip**

What is femoral anteversion?



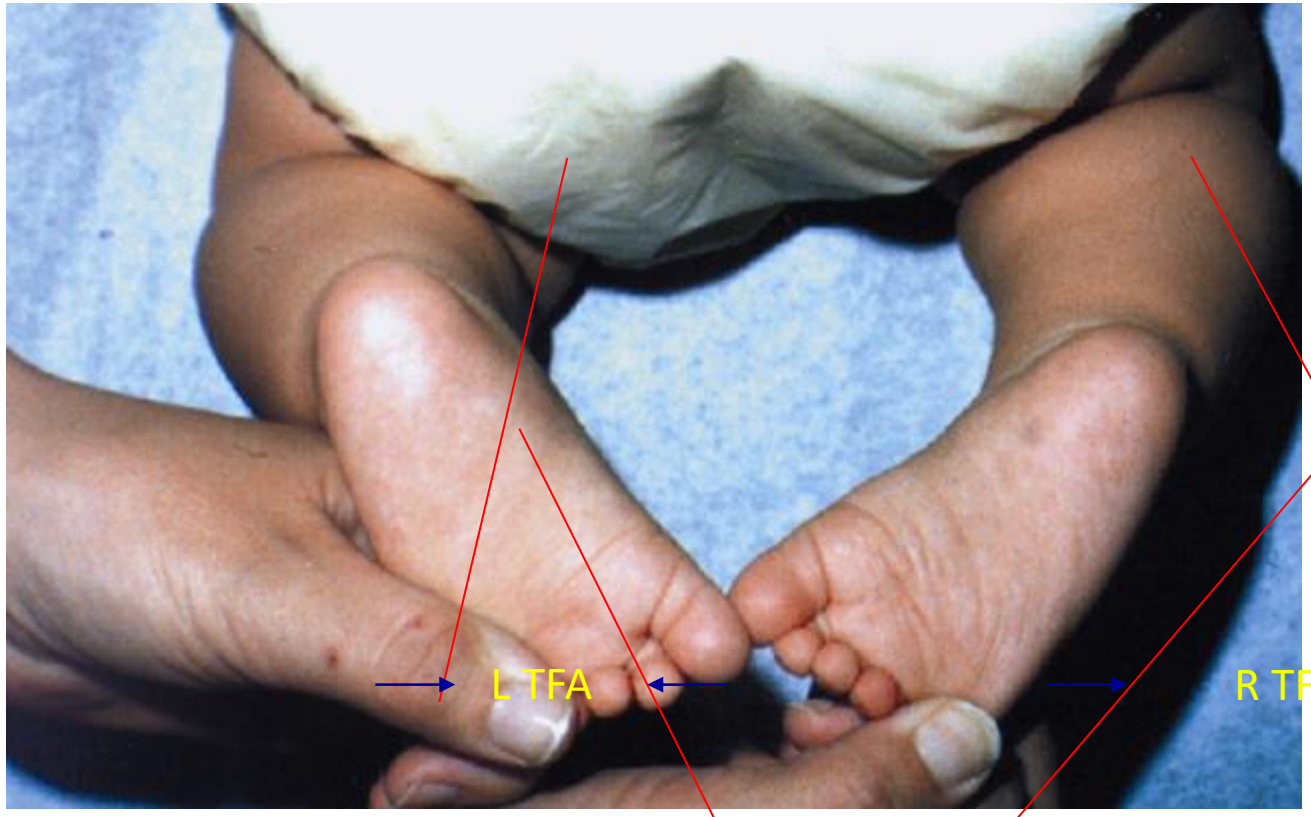
Femoral antetorsion produces intoeing

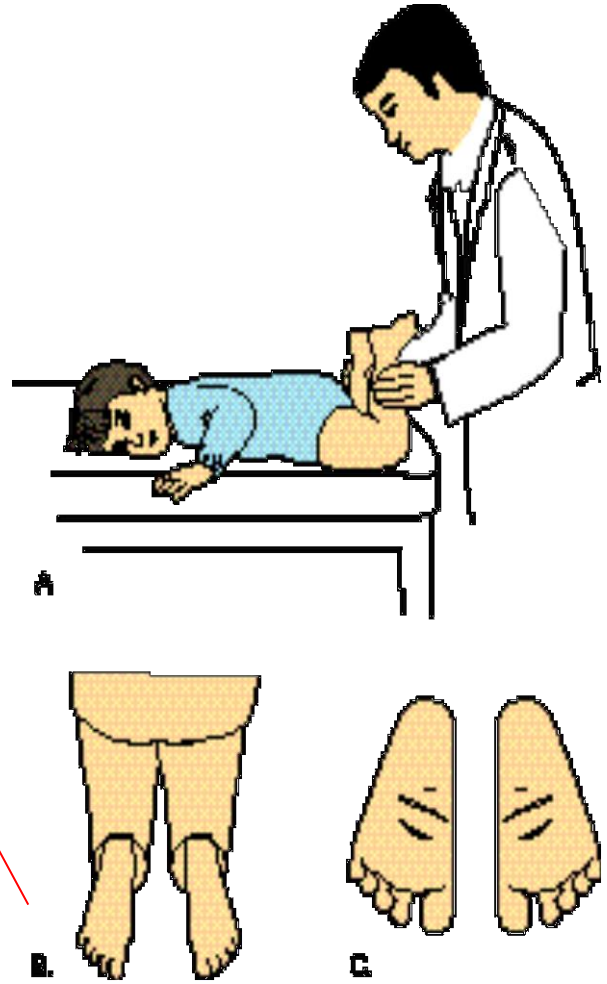
Femoral antetorsion

- Usually 3-5 y girls
- Sits in the “W”
- “Kissing patellae”
- “Egg-beater” run
- Severe if > 90°
- Resolves with growth

Assessing tibial torsion:

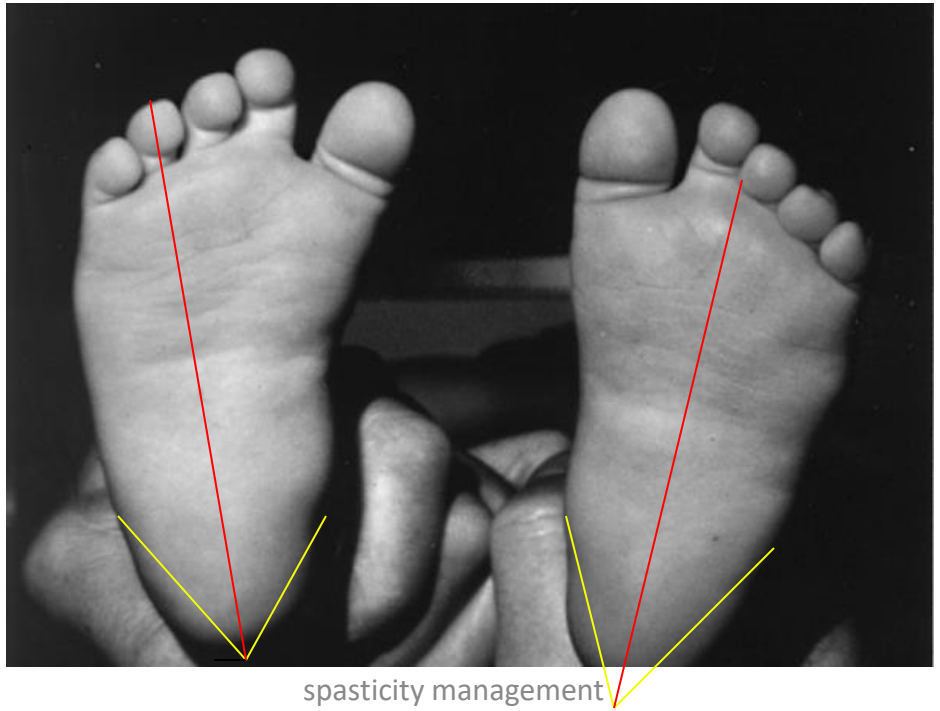
- Thigh-foot angle
- Transmalleolar axis





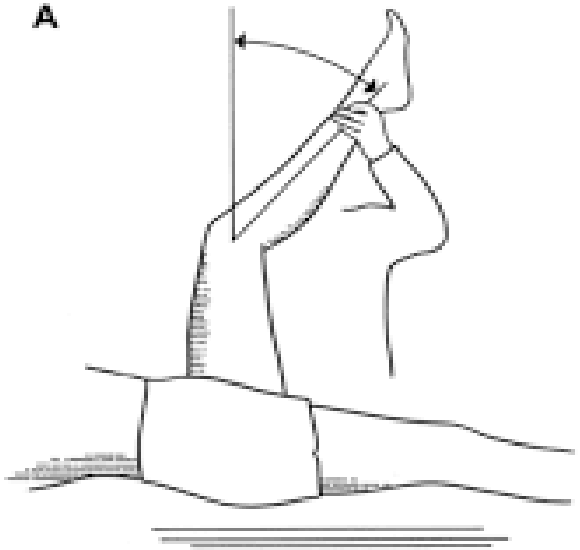
Assessing alignment of the foot

- Shape of the foot
- Heel-bisector angle



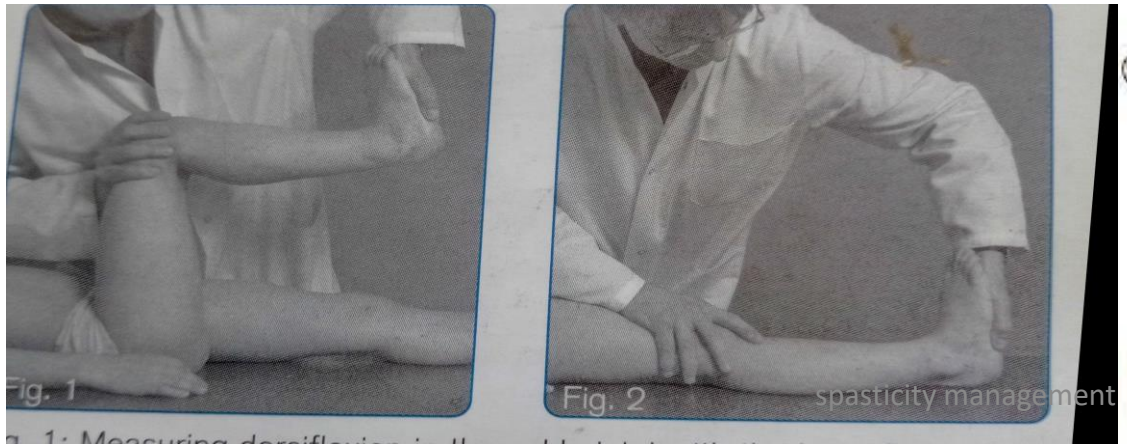
Knee flexion deformity test

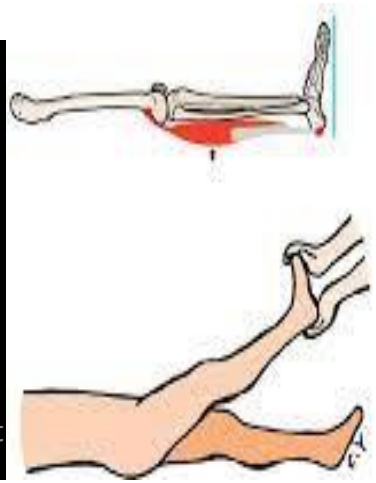
- Sitting-with-feet-in-front test: in shortened hamstrings, knees flexed with internal hip rotation
- Popliteal angle



Triceps surae shortening test

- Tardieu test
- Silfverskiold test: It differentiates between soleous (dorsiflexion with the knee flexed) and gastrocnemius (dorsiflexion with the knee extended)
- Selective motor control of the foot





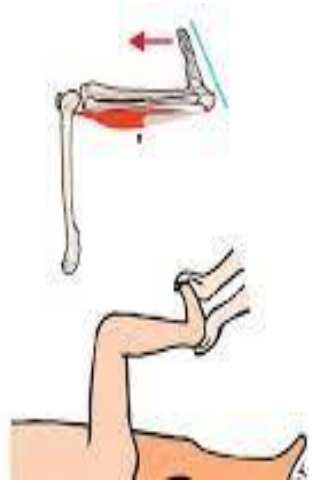



Fig. 1
Fig. 2
ig. 3
g. 4
g. 5

Treating spasticity is aimed at :

- reducing muscle spasm and pain
- facilitating therapies
- reducing contractures and deformities
- improving posture, mobility, and motor function
- helping with caregiving tasks

- In some cases, reducing spasticity may uncover other symptoms such as weakness

- Therefore, when initiating therapies to reduce spasticity, careful monitoring is necessary to ensure benefits outweigh risks

- In cases in which improving spasticity is helpful, nonpharmacological therapies such as physical and occupational therapies, stretching, and the use of orthotics must first be optimized before initiating pharmacotherapy

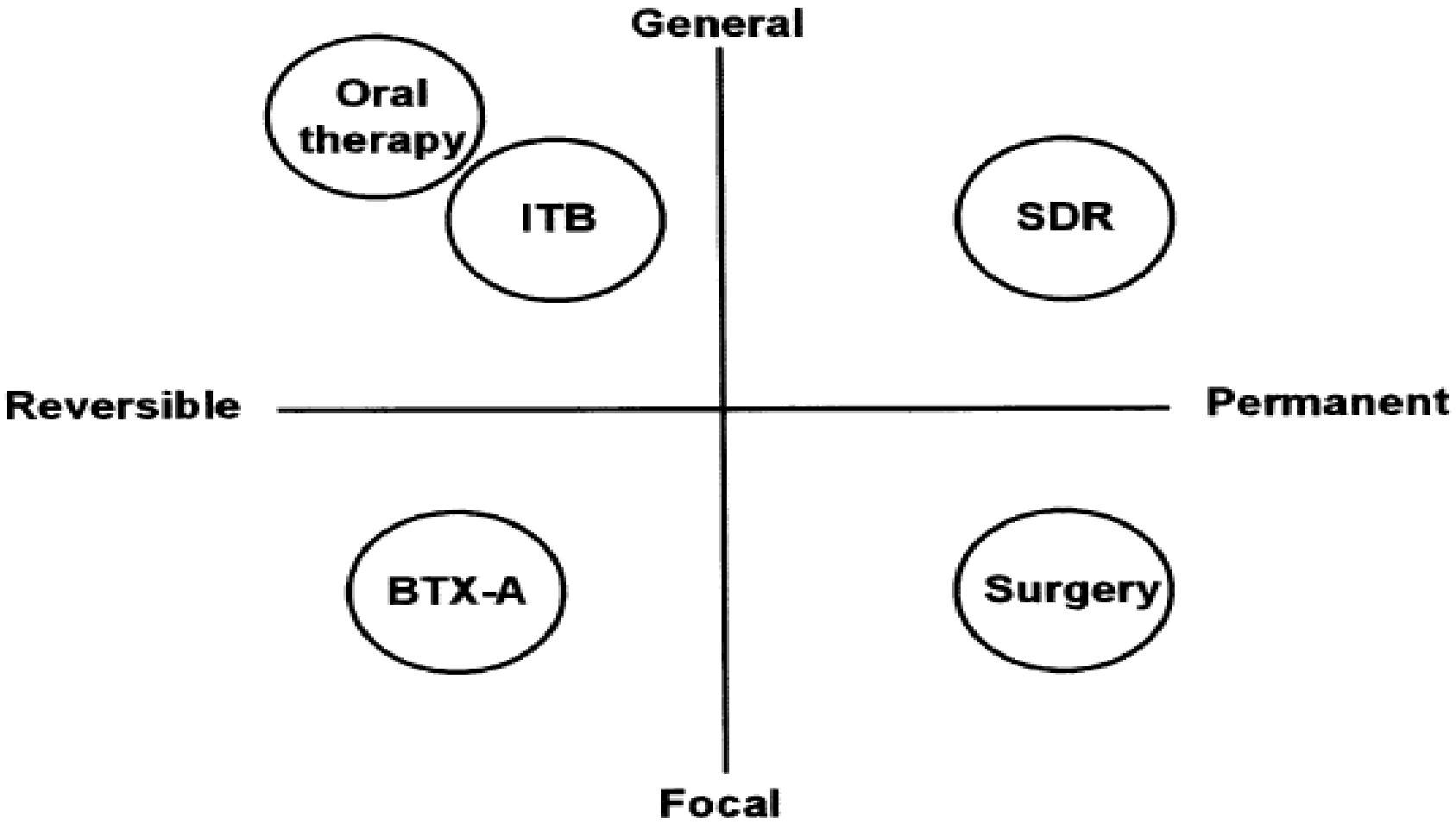
Spasticity management

- Medical management
- Rehabilitation
  - Positioning
  - Stretching
  - W.B
  - Strengthening
  - Orthotics

Pharmacological Agents

- **Oral Baclofen**
- **Diazepam**
- **Tizanidine**
- **Clonidine**
- **Dantrolene**
- **Intrathecal baclofen**
- **Botulinum toxin A**

Spasticity management



Casting

- Serial casting may serve to reduce spasticity in muscles by decreasing the strength of abnormally strong tonic foot reflexes.(Bertoli 1996).
- Serial casting in the CP population has been shown to improve ROM.(Brouwer 2000)
- Casting provides stability and prolonged stretch of a muscle which is immobilized in a lengthened position(Mosley 1997).
- Novak proposed that Casting is a good method of contracture management in UE and LE (2013)

BTX-A


BOTOX®
Powder for solution for injection
Botulinum toxin type A
One vial contains 100 units of
Botulinum toxin type A*
(from Clostridium botulinum)
Vial of
100
UNITS*
ALLERGAN
BOTOX®


C:15054-0500-1
bobotulinumtoxi
Dysport
for Injection
For intramuscular use
500 units/vial
15054-0530-6
bobotulinumtoxin
Dysport
for Injection
For intramuscular use
300 units/vial

Botulinum toxin A

- botulinum toxin A is the only BTX-A that has received FDA approval for the treatment of lower limb muscle spasticity in children aged 2 years and older

- It inhibits the release of acetylcholine at the neuromuscular junction

- This leads to focal weakness, reduced muscle tone, and ultimately a reduction in spasticity

- BTX-A is not expected to be absorbed into the blood stream following intramuscular administration; therefore, little is known about the pharmacokinetics

- The onset of action occurs anywhere from 4 days to 4 weeks, peak effects within 4–6 weeks, and duration of effect typically around 3 months

- **Although BTX-A has localized effects, systemic side effects may include :**
- upper respiratory tract infection
- generalized weakness
- Pharyngitis
- Dysphagia
- Repeated injections can result in the development of antibody resistance; therefore, injections should occur no more frequently than every 3 months

- The efficacy of BTX-A is supported in the literature and in practice and is overall well tolerated

- BTX-A improves muscle tone, ease of care, and comfort

- It is also associated with comparatively fewer adverse effects than oral medications and should be considered in those patients who fail oral therapies owing to a lack of efficacy or toxicity and/or are not eligible for ITB

BTX-A

- Target muscles in LE

➢In more severe cases: medial hamstrings and adductors

➢ in less severe cases: hamstrings or calf, or occasionally adductors and calf

➢ In hemiplegia: 1. calf 2. hamstring

➢ In diplegia: 1. hamstrings 2. calf

➢ In quadriplegia: 1. adductors 2. calf and hamstrings

- Repeated exposure to BTX-A can lead to immunoresistance
- Novak proposed that BTX-A is a good method of spasticity management in children with CP(2013)
- BTX-A reduces spasticity and improves ambulatory status.(Flett 1999)

BTX-A + casting/orthosis

- When used in combination with casting it has shown to help maintain and improve muscle length and passive ROM.(Kay 2004)
- If the contracture is early, soft and mild, then WB together with orthoses and stretching may be sufficient for management of calf and hamstring following BTX-A.
- If contracture is more fixed but some dynamic range of motion is available, consider BTX-A supplemented after 3 weeks by a short period of casting to alleviate the residual contracture

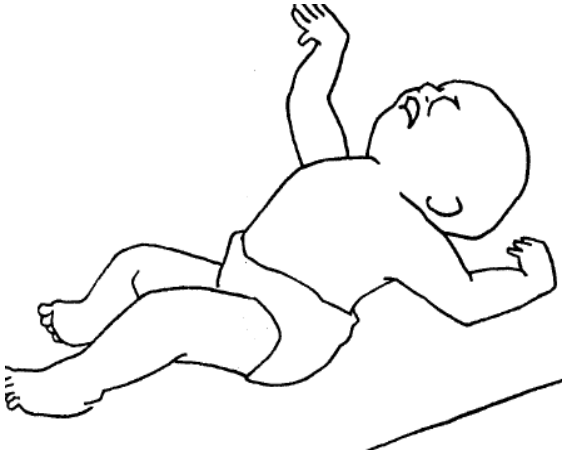
BTX-A plus therapy/Orthosis

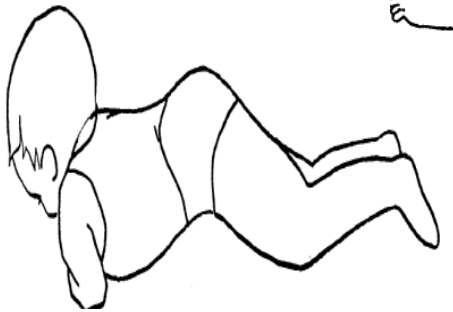
- Fehlings et al showed that upper extremity injections of BTX-A plus OT were superior to OT alone on the QUEST.
- Orthoses are used in conjunction with PT/OT to facilitate carry-over of improved motor control following BTX-A injection, particularly in the LE.

Principles of treatment

- Analyze the predominant pattern of spasticity that is interfering with function
- Use patterns with wide ranges of movement
- Avoid functional activities which increase flexion—e.g., crawling, kneeling, W-sitting
- Work for righting, EQUILIBRIUM and protective reactions, to decrease fear
- Avoiding too much stimulation and effort.
- Avoid using stereotyped patterns of movement for function—find ways to break them up(bunny hopping)
- Use of tone-influencing patterns (TIPs)

Analyse the predominant pattern of spasticity that is interfering with function

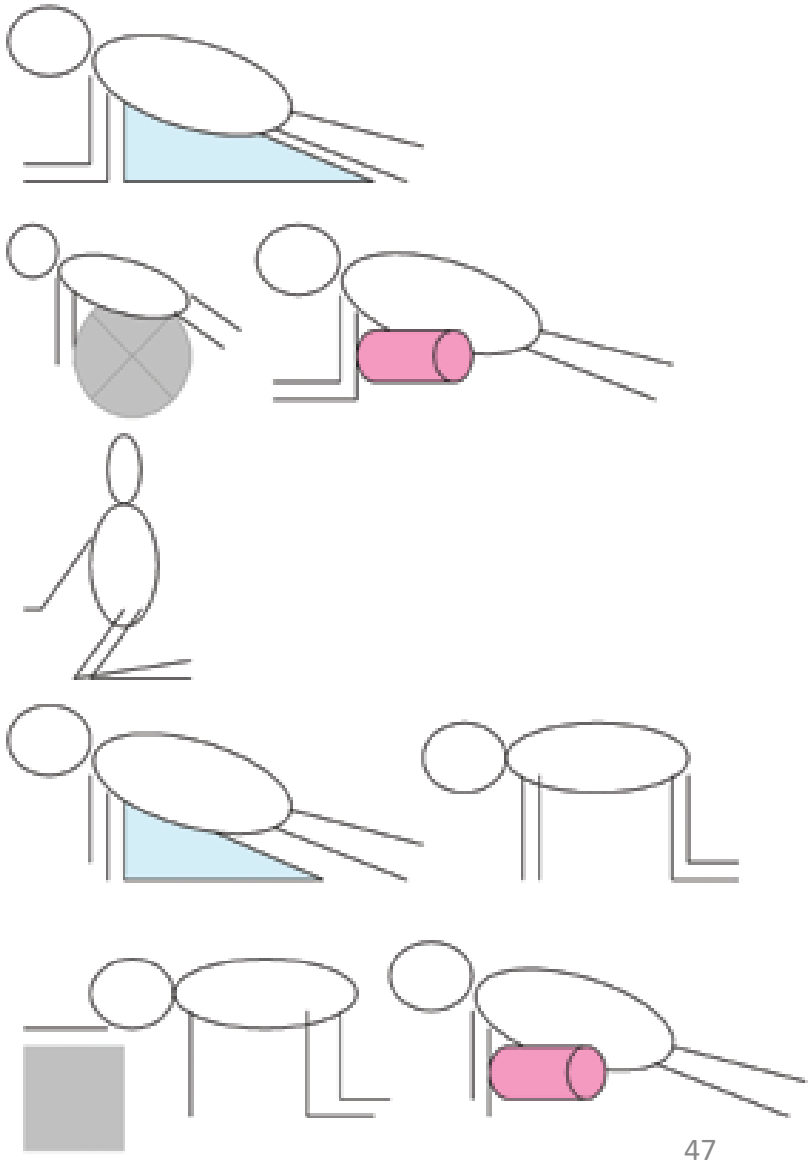




- Poor positioning can lead to worsening spasticity.
- Body alignment
- Greater symmetry
- Some Posture that should be avoided.

Weight Bearing

- Dynamic weight-bearing reduces spasticity and facilitate more normal postures and movements
- Low intensity vestibular stimulation such as slow rocking produces generalized inhibition of tone(rocking in chair, Swiss ball, equilibrium board, hammock, slow rolling movement)
- static weight bearing inhibits activity of muscles spindles thereby reducing spasticity.
- Facilitated weight bearing and weight shifting can build strength, improve co-contraction, and improve postural symmetry and alignment.
- weight bearing through progressively decreasing the base of support develops balance and equilibrium reaction



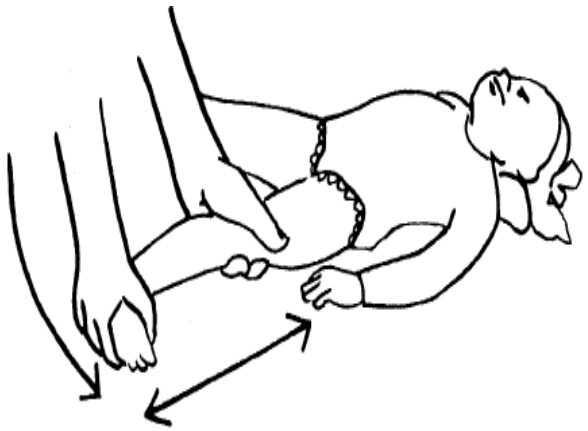
Tone and techniques of handling

Abnormal postural tone	*Handling technique*	*Aim of use of technique*	*Comment*
Released tonic reflexes (1940s)	Reflex inhibiting postures (RIPs)	Inhibition of released tonic reflexes	Static — little or no movements; often opposite to pattern of spasticity
Abnormal tonic (postural) reflex activity (1960s)	Reflex inhibiting patterns (RIPs)	Simultaneous inhibition, facilitation & stimulation	Emphasis on facilitation of postural reactions
Abnormal neural and non-neural aspects of tone (1990 — present)	Tone influencing patterns (TIPs)	'Inhibition', facilitation, stimulation and biomechanical influences	Influence both the control of posture and task performance

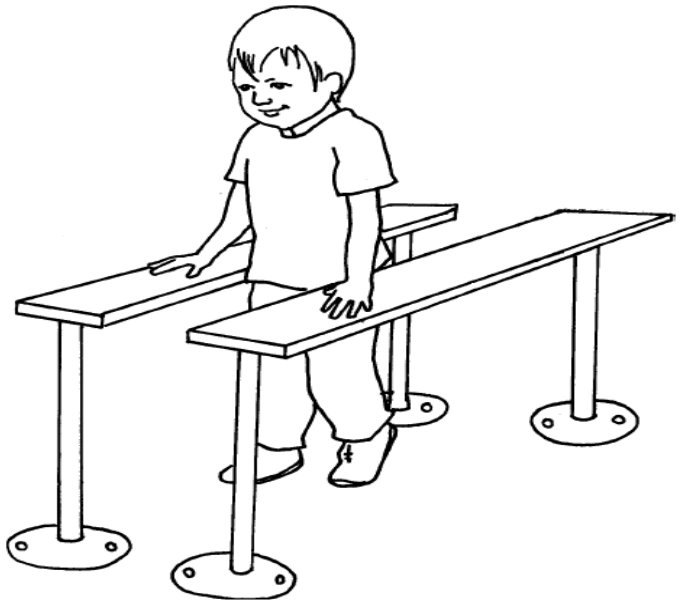
Tone Influencing Pattern

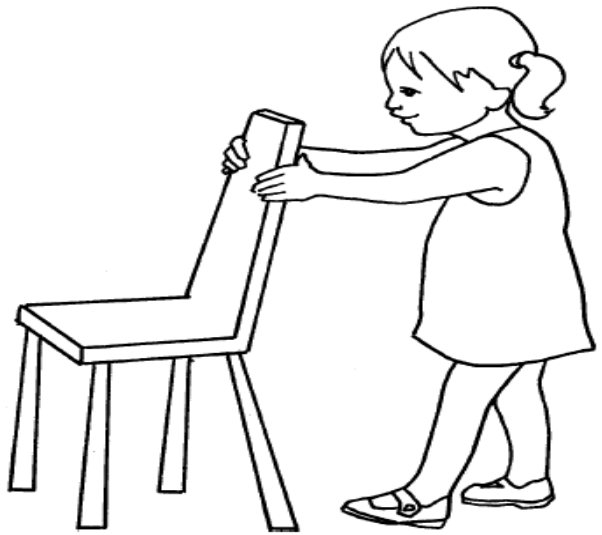
Key point and tone-influencing pattern (TIP)	*Likely effect*
Child prone, head and neck extended, shoulder girdle retracted	Facilitates extension in rest of body
Child supine, head and neck flexed, shoulder girdle protracted	Reduces extensor spasticity
Inward rotation of shoulder with protraction of shoulder girdle	Reduces extensor spasticity and is useful in athetoids (used carefully) but in children with spasticity it increases flexor spasticity of neck, trunk and lower limbs
Outward rotation of shoulder with supination and elbow extension	Reduces flexion and increases extension in the rest of the body
Horizontal abduction of arms in outward rotation with supination and elbow extension	Reduces flexor spasticity. Facilitates opening of hand Facilitates abduction of the legs with outward rotation and extension if spine is also extended
Extension of arms backwards in prone, sitting or standing with spine extended	Reduces flexor spasticity. Has same effect as in horizontal abduction but easier to achieve when there is more spasticity
In sitting, prone or standing abduction of thumb with arm in outward rotation and supination	Facilitates opening of the fingers
Outward rotation of the legs in extension	Facilitates abduction of the hips and dorsiflexion of the ankles

Handling



Use of adaptive equipment





Anti-Spastic orthotic Goals

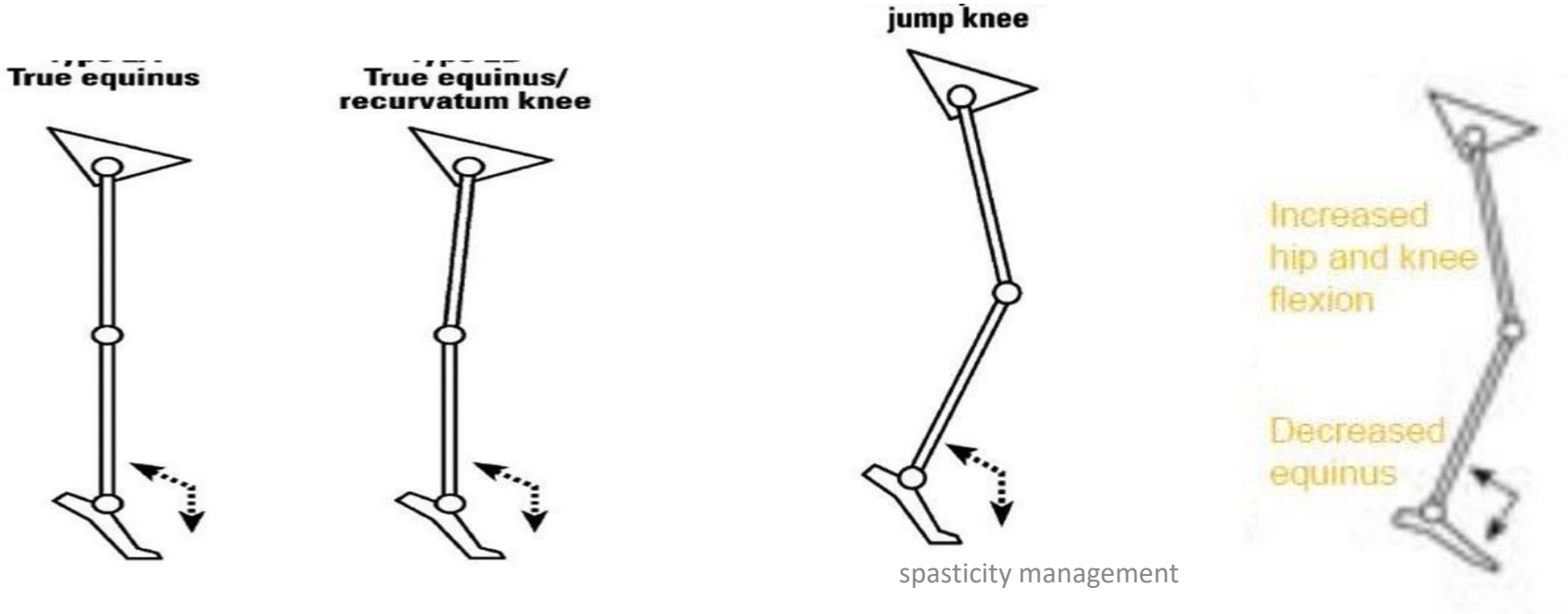
- To correct and/or prevent deformity
  - The deformities caused by relative shortening of muscles and soft tissues cannot be passively corrected and must be accommodated in orthoses.
  - Ensuring that muscles spend more than 6 hours during each 24-hour period in an elongated position may help to prevent or reduce the rate of progressive contractures.
- **To Facilitate Training in Skills**
  - For UE, using wrist orthoses to facilitate manual dexterity when grasping objects.
  - For LE , the effects include influencing external movements acting around proximal joints by altering the line of action of the ground reaction force during standing and walking
- To provide a base of support
  - Hip abduction orthoses may improve stability and sitting balance by increasing the BOS
  - AFO can increase the BOS in toe walkers.
- To improve the efficiency of gait
  - Orthoses may reduce energy expenditure by decreasing the need for compensatory gait deviations to achieve locomotion.
  - Orthoses can improve the gait in both stance or swing phases

Lower Extremity Spasticity

- Spasticity and passive resistance to muscle stretch particularly influence biarticular muscles, such as the rectus femoris, hamstrings, and gastrocnemius, which require greater excursion across two joints.
- Impaired muscle growth and muscle fiber changes result in a shortened muscle-tendon unit in the muscles affected by spastic CP.
- The failure of muscle growth to keep pace with bone growth is most evident in the biarticular muscles and contributes to joint contractures and gait abnormalities such as toe-walking and flexed-knee gait.
- The short muscle-tendon unit also likely contributes to Weakness.

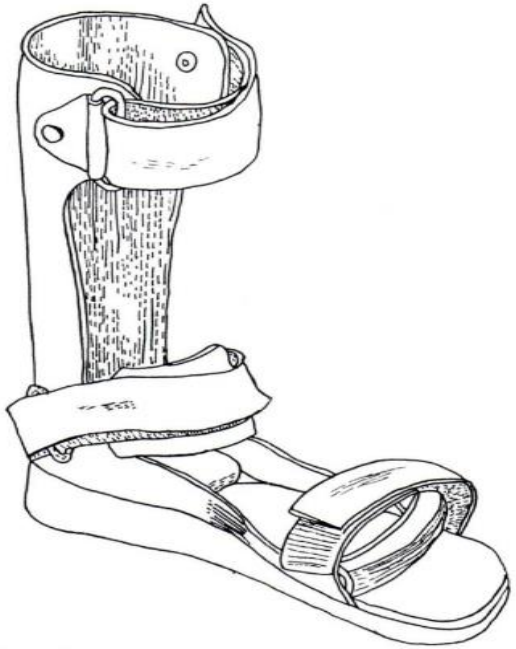
Ankle-Foot Spasticity in Children with CP

- Ambulating children with GMFCS I-III
  - Plantar flexors including the gastrocnemius and soleus in gaits such as true equinus, jump gait, and apparent equinus in spastic hemiplegia and diplegia.
- Non-ambulating Children with GMFCS IV-V
  - prevent/control deformities
  - facilitate supported standing in standing frames



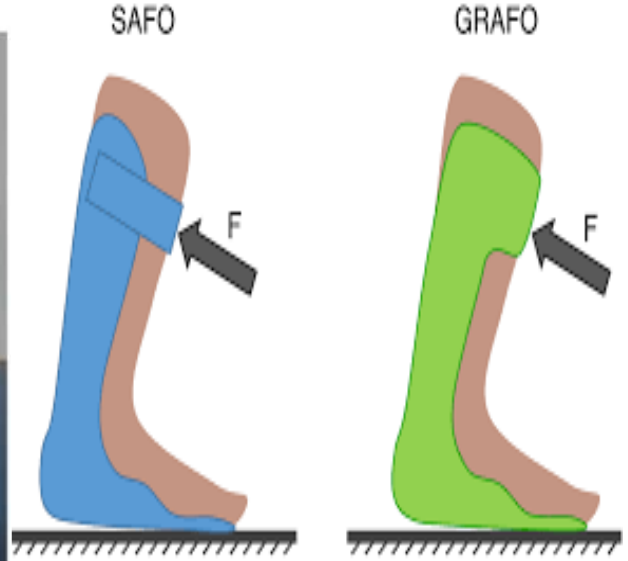
True equinus

- True equinus is noted in the stance phase of gait because of the spasticity and / or contracture of the gastroc-soleus muscles.
- Solid AFO, High top shoe, tone reducing orthoses is recommended for type 1 true equinus.
- Inhibitor metatarsal bar could reduce toe flexion spasticity
- If the knee is in recurvatum, a hinged AFO with plantar flexion stop is the most appropriate choice. A plantar flexion stop or posterior stop in an AFO is designed to substitute for inadequate strength of the ankle dorsiflexors during swing phase of gait.



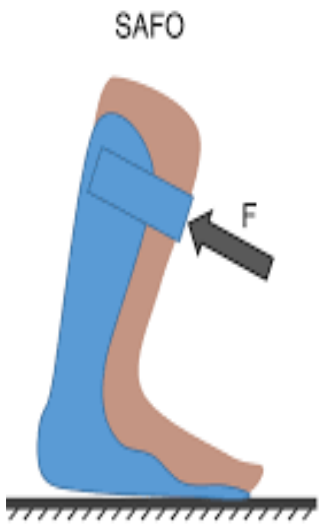
Jump gait

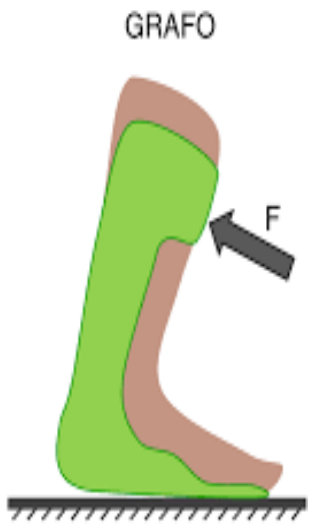
- The jump gait pattern is very commonly seen in children with diplegia.
- The ankle is in equinus, the knee and hip are in flexion, there is an anterior pelvic tilt and an increased lumbar lordosis. There is often a stiff knee because of rectus femoris activity in the swing phase of gait.
- In younger children, this pattern can be managed effectively by BTX injections to the gastrocnemius and hamstrings and the provision of an AFO.
- Different AFOs can be recommended such as tone reducing, Solid AFO, Hinged AFO, and GR AFO



Apparent equinus

- It defined by a foot position that is normal in relationship to the tibia, however heel strike does not occur due to more proximal deviations (flexion of the knee most common)
- As the child gets older and heavier, this pattern may be progress.
- Equinus may gradually decrease as hip and knee flexion increase.
- Sagittal plane kinematics will show that the ankle has a normal range of dorsiflexion but the hip and knee are in excessive flexion throughout the stance phase of gait.
- Redirection of the ground reaction vector in front of the knee can best be achieved by the use of a solid or a ground reaction AFO.
  - **Hinge AFO with dorsiflexion stop.**
  - **Solid AFO**
  - **GR AFO**





Knee muscles spasticity

- **Stiff Knee Gait**
  - AFO SA or Hinged AFO with PF stop
- **Crouch gait**
  - AFO SA: in joint contracture is not indicated
  - GR AFO
  - Hinged AFO with dorsiflexion stop
  - KAFO and KO : Genovalgum correction and knee flexion deformity control, Adduction control

Hip/pelvic muscles spasticity

- Scissoring Gait
  - KAFO with spreader bar
  - Atlanta/scottish–Rite hip abduction orthosis
  - Sitting Walking And Standing Hip (SWASH)
- Hip Flexion contracture
  - Dial Hip orthosis
  - HKAFO
- Hip int Rot
  - Denis Brown splint
  - SWASH