A Pocket Guide to Musculoskeletal Assessment of Children with CP

Paediatric Update Symposium
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Objectives

1. What should be monitored in the community (lower extremity)?
2. When should a child be referred to orthopaedics?
3. When should the upper extremity be assessed?
4. How can therapists assist in preparing a child for surgery?

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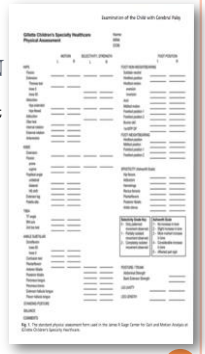
Physical Examination



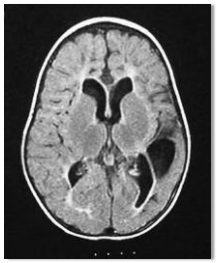
1. **Range of motion (ROM) & contractures**
2. **Muscle tone**
3. Selective motor control
4. Strength
5. **Bone torsion & deformity**
6. Posture
7. Balance
8. **Gait**
9. **Functional Mobility**

Novacheck et al., Orthop Clin N Am 2010; 41: 469-488

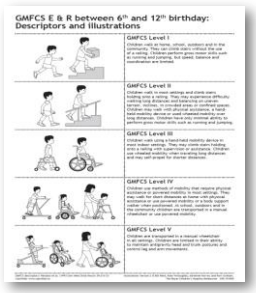
Time!

What you should already know

- History
- Diagnosis*
- Topography
- Motor type
- Classifications



Classifications



Watch for → "Contractures"

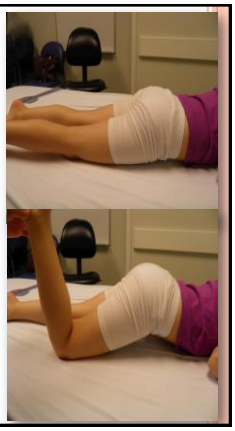
Loss of ROM

- Static or dynamic?
- Primarily 2 joint muscles effected:
  - Gracilis
  - Rectus femoris
  - Hamstrings
  - Gastrocnemius

Novacheck et al., Orthop Clin N Am 2010; 41:469-488

Hip flexion contracture

- Psoas or rectus femoris?
- Pelvis position affects hamstring length



Gage et al., 2nd Edition, 2009; Novacheck et al., Orthop Clin N Am 2010; 41:469-488

Knee Flexion Contracture

- Hamstring contracture, followed by posterior knee capsule
- Moderate contracture = 10-30º
- Severe contracture = >30º
- Contractures of <10º not mechanically significant but can drive further contracture/crouch posture

Usually starts at 5-7 years of age

Miller F. 2005

Equinus - Silverskiold Test

Knee flexed - soleus

Knee extended - gastrocs

EQUINUS

- Excessive plantarflexion of the hindfoot relative to the ankle
- Most common orthopaedic deformity in children with CP
- Spasticity and/or contracture in gastroc ± soleus
  - Hemiplegia: soleus often contracted
- Extreme cases can include hindfoot and forefoot

- Age 18-24 mo: start to develop
- Age 4-7 years: dynamic
- By 6-7 years: fixed equinus starting to develop

Miller F, 2005; Davids J. Orthop Clin N Am 41 (2010) 579–593; Sees & Miller. J Child Orthop. 2013;7:373-377

CONTRACTURE OR SPASTICITY?

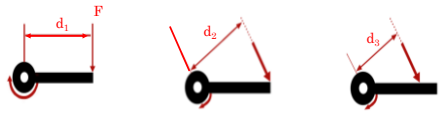
- Either can restrict ROM
- Important to assess spasticity
- Can direct treatment
- Static findings ≠ dynamic findings
- ROM assessment during sleep, under general anesthetic
- Tardieu Scale (R_1, R_2)

Gage et al., 2nd Edition, 2009; Novacheck et al., Orthop Clin N Am 2010; 41:469-488

WATCH FOR → BONE TORSION & DEFORMITIES

Lever Arm Dysfunction

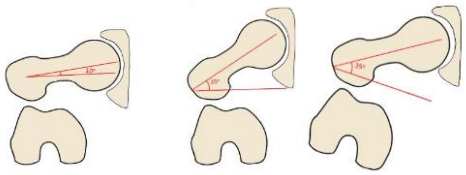
- Moment arm of a muscle varies with the position of the body and the bony geometry
- Muscles work most effectively on rigid bony levers in the line of progression



$d_1 > d_2 > d_3$
$M_1 > M_2 > M_3$

Rodda & Graham, Eur J Neurol 2001, 8 (Suppl. 5): 98±108;

Increased Femoral Anteversion



Normal Anteversion

Persistent Femoral Anteversion

Internal Tibial Torsion

- 2nd most common cause of intoeing gait (almost equal to femoral anteversion)
- Contributes to both lever arm dysfunction and tripping
- As per typically developing children, torsion will not remodel after age 8-10 years

Rethlefsen SA et al. J Bone Joint Surg Am 2006 Oct; 88(10): 2175-80.

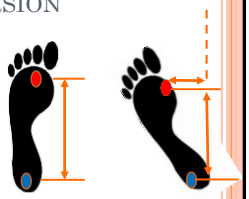
Patella Alta

- Constant force causes patella gradually moves more proximal
- Associated with quadriceps insufficiency
- May contribute to patellofemoral instability, pain, and subluxation
- Ambulatory & non-ambulatory children

Miller F, 2005; Novacheck et al. Orthop Clin N Am 41 (2010) 469–488

External Tibial Torsion

- Results in mal-rotated lever arm
  - Abnormal axis of joint motion relative to the line of progression
  - Affects function of the foot in power generation
  - Introduces valgus and external rotation forces



Er MS et al. *J Pediatr Orthop* 2017; 37(7): 454-459.; Hicks J, et al. Gait Posture. 2007;26:546–552; Gage JR et al. 2nd Ed, 2009

Equinovalgus

- Equinus deformity of the hindfoot, pronation deformities of the midfoot and forefoot.
- Lateral column of the foot functionally and/or structurally shorter than the medial column
- Often associated with ankle valgus and hallux valgus

Davids J. Orthop Clin N Am 41 (2010) 579–593

Midfoot Break

- Increased tightness in the gastroc-soleus pulls the hindfoot and talus into equinus
- Overpower the tibialis posterior and spring ligament causing a collapse of the longitudinal arch
- Forefoot position is dorsiflexed, abducted and supinated relative to the hindfoot
- Navicular becomes subluxated dorsally and laterally on the talus

Equinovarus

- Cause = tibialis anterior, tibialis posterior, or both
- Common in hemiplegia; stable or persists
- In diplegia, almost all overcorrect into valgus in late childhood or adolescence; high risk of overcorrection if surgically treated at a young age (under 8 years)

Common in young children aged 3-7 years

Sees & Miller. J Child Orthop. 2013;7:373-377: Aiona &Sussman. J Pediatr Orthop B. 2004; 13(3) S13-S38.

Watch for → gait abnormalities

Maturation of Gait

- Sagittal plane mature (heel toe pattern) by 3.5 years
- Fully mature typical gait by approx. 7 years
  - Ie. step length, cadence, step-width, single-limb stance

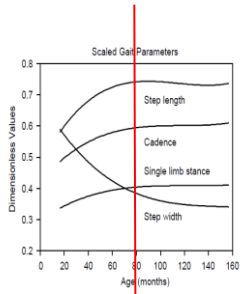
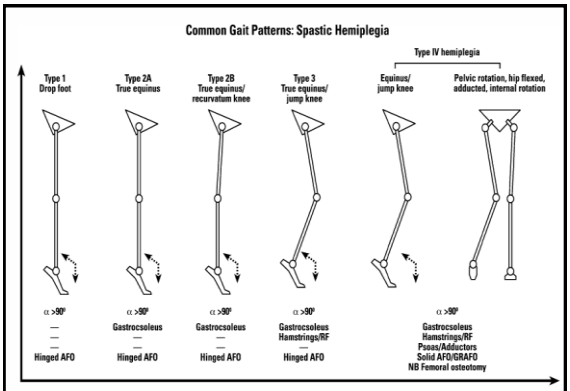


Fig. 5. Fundamental gait parameters, scaled according to Hof (1996), change during the first 6 years (72 months) of life and are thereafter invariant with age (Vaughan et al., 2001).

Gage et al. 2nd Edition, 2009; Vaughan CL, J Biomech, 2003

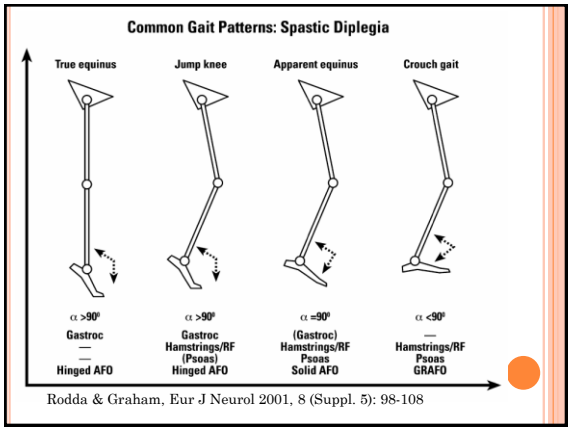


Rodda & Graham, Eur J Neurol 2001, 8 (Suppl. 5): 98-108

Leg Length Discrepancy in Hemiplegia

- Anatomically shorter limb on the hemiplegic side
  - Greatest difference in the tibias, also smaller foot (calcaneus/talus)
  - Femur showed no significant difference (Riad et al. 2010).
- Might be an advantage in swing phase to allow foot clearance in swing when dorsiflexion ROM is limited/stiff knee gait
- Surgical options for more severe (≥4cm)

Riad et al. J Pediatr Orthop 2010;30:846–850



Rodda & Graham, Eur J Neurol 2001, 8 (Suppl. 5): 98-108

Changes in Gait with Age

- Increasing age saw increase in:
  - Rotational malalignment between the femur and tibia
  - Calcaneal gait
  - Out-toeing
  - Varus/valgus foot deformities
  - Hip internal rotation

Wren et al., J Pediatr Orthop 2005;25:79–83

Watch for → functional deterioration

Predicting Deterioration

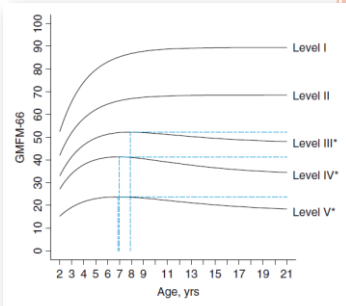
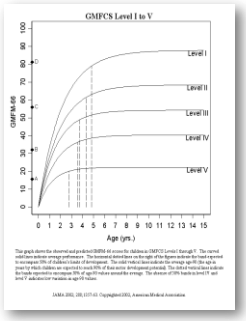
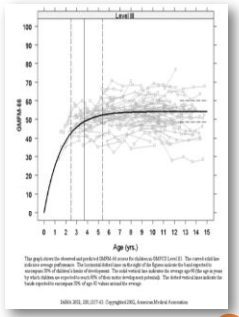


Figure 1: Predicted Gross Motor Function Measure (GMFM-66) motor scores as a function of age by Gross Motor Function Classification (GMFCS) level. *GMFCS levels with significant average peak and decline. Dashed lines illustrate age and score at peak GMFM-66.

Hanna et al., *Dev Med Child Neurol*, 2009;51:295-302





Functional Mobility Scale

6 – Independent on all surfaces
5 – Independent on level surfaces
4 – Uses sticks (one or two)
3 – Uses crutches
2 – Uses a walker or frame (without help)
1 – Uses wheelchair
C – Crawls
N – Does not apply – child does not complete the distance (500m)

Harvey et al., Phys Occup Ther Pediatr, 30(2): 139-149.

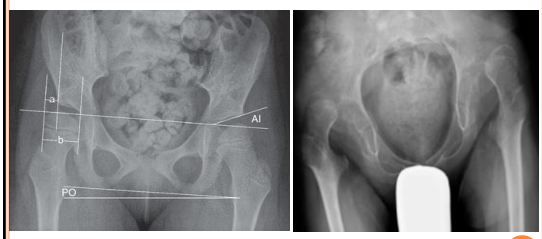
Watch for → complications

Hip Displacement

- Second most common musculoskeletal deformity affecting children with cerebral palsy after equinus
- One in three children with CP will have hip displacement
  - 3 population based studies (35,27,32%).
- Hip is normal at birth
- Changes seen on x-ray as early as 12 months of age

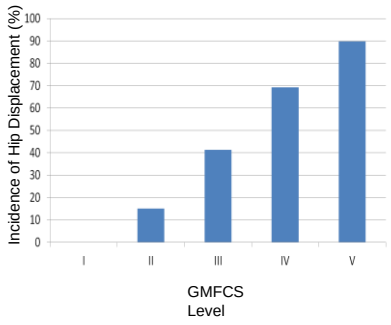
Cornell, 1995; Soo B et al., 2006; Hagglund et al., 2007; Connelly et al., 2009

Hip Displacement & Dislocation



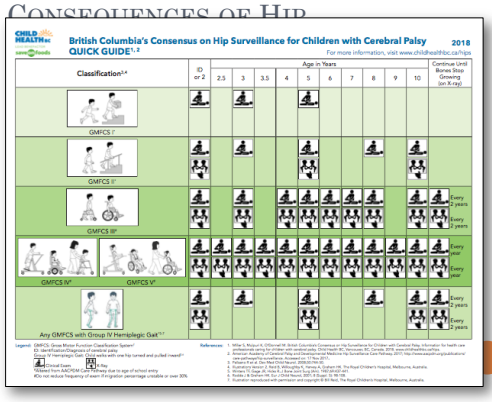
A silent problem

Risk of Hip Displacement



Soo et. al,. J Bone Joint Surg [Am]. 2006, 88, 121-129.

Consequences of Hip



Windswept Hips

- Abduction and external rotation of one hip
- Opposite hip in adduction and internal rotation

Figure 1: Lower extremities - Distortion Process.

Swick J. Yoga Phys Ther 2014; 4:3.

Spinal Deformities

- Earlier onset for those at higher risk
- Incidence found to increase into early adulthood
- Greater deformity in sagittal plane (kyphosis, lordosis)
- Causes unknown
  - Weakness, trunk imbalance, tone asymmetry?

Hagglund et al. Acta Orthopaedica; 2018: 89: 443-447; Imrie & Yaszay, Orthop Clin N Am 41 (2010) 531–547

Scoliosis in CP: Swedish Population

- Frequency and severity of scoliosis increased with GMFCS levels
  - Level I: 0-1%
  - Level V: 42-55% (CE/Xray)
- GMFCS V
  - 20% at age 10
  - 75% at age 20

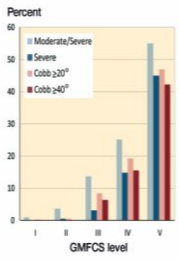


Figure 1. Percentage of individuals at GMFCS I–V with moderate or severe scoliosis at clinical examination and with a Cobb angle exceeding 20° or 40° at radiographic examination. Individuals with Cobb ≥ 40° are also included in the presentation of Cobb ≥ 20°.

Hagglund et al. Acta Orthopaedica; 2018: 89: 443-447

Fractures in Children with CP

- Fractures related to low trauma
- Associated with low BMD
- Typically long bones & spine (often supracondylar femur or shaft)
- More common at GMFCS IV/V
- Can go undetected
- Mechanism can be unclear

Risk of Fractures

Wort et al. (2013)

- Reviewed factors associated with fracture in 536 children
- GMFCS I-III: no increased risk without trauma
- GMFCS IV-V: 5X ↑ risk with slight or moderate trauma (when stunted growth, epilepsy)
  - ↓ risk with g-tube
  - ↑ risk with no standing
  - Still 4X risk without trauma

Wort et al., Dev Med Child Neurol, 2013;55:821-827

Pain & CP

- Children with CP have greater reports of pain than peers
- ~50-70% (self- vs. parent-report)
- Increases with increasing age
- Across GMFCS levels
- More often in those with lowest gross motor function
- Impacts participation, sleep, energy, mood, QOL

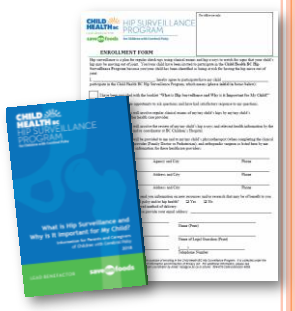
Musculoskeletal (MSK) Pain

- Most common source in children with higher impairment *(McDowell et al., 2017)*
- Feet, knees, & hips most common areas *(Westbom et al, 2017)*
- Pain correlated with functional decline in school aged children *(Bartlett et al., 2010)*
- 1/14 had chronic pain - 50% undocumented *(Westbom et al, 2017)*

When to consider referral?

Hip surveillance

- Does not require orthopaedic referral!
- All children with CP (or suspected) should be enrolled
- If unsure, please contact program: hips@cw.bc.ca



Enrolling in hip surveillance ≠ orthopaedic referral

Common reasons for referral

Ambulatory	Non-ambulatory
Tone, ROM, alignment, deformity impacting function	Pain or discomfort
Decline in gait	Tone, ROM, alignment impacting positioning, care
Decline in function	Brace intolerance
Brace intolerance	Seating intolerance
Pain or discomfort	Decline in function
Deformity impacting appearance	Complications (spine, fracture, hip)
Caregiver concerns	Caregiver concerns

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Other considerations

- Time sensitive – skeletal maturity
- Gait lab analysis
- Primary care
- Other investigations?

Contact us!

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Assessments for CP:

- **Assisting Hand Assessment (AHA)**
- **Shriner's Hospital Upper Extremity Evaluation (SHUEE)**
- **Bimanual Fine Motor Function (BMFM)**

WHO? Should be referred

MACS 1-5	• Contractures of the upper extremity for splinting +/- Botox injections.
MACS 1-3	• Tendon lengthening or transfer to rebalance; elbow, forearm, wrist, thumb
MACS 4-5	• Skincare, hygiene or care is difficult due to contractures

WHAT? Should be screened

Hemiplegic CP

- Effectiveness of grasp to hold for dominant hand to manipulate against?
- AROM/PROM
- Pattern of spasticity/deformity during functional tasks
- Observe spontaneous use

Constraint Induced Movement Therapy and Bimanual Training

Health Policy & Clinical Effectiveness Program

Evidence-Based Care Guideline

Pediatric Modified Constraint Induced Movement Therapy (mCIMT) plus Bimanual Training (BIT)[a]

Publication Date: December 2014

Sakzewski et al. Pediatric modified Constraint Induced Movement Therapy (mCIMT/BIT) Team, 2014; Pediatrics 2014;133:e175–e204

CIMT & Bimanual

- At the same intensity, both interventions equally as effective in improving hand function
- CIMT appears to provide greater gains in unilateral skill
- BIT training shows greater gains in bimanual function
- Trend to implement CIMT followed by bimanual training

What? Should be screened

Quadriplegic CP

- Are resting splints required to maintain PROM for skincare and hygiene?
- Are splints tolerated?

Surgical outcomes in Upper Extremity Deformities in CP

- Van Heest AE, House J, Cariello C. Upper Extremity Surgical Treatment of Cerebral Palsy. J Hand Surg 1999; 24A:323-330
- Review of 25 year of surgical treatment at all levels of the upper extremity.
- Does surgical intervention improve function?
- Children with fair and good voluntary control had significantly greater improvement.
- No other predictive factors (sensation, intelligence, motor control, type of CP)

Common Surgical Procedures

- Lengthening of spastic muscles
- Augementation of weak muscles with tendon transfer
- Boney fusions

Wrist

Clinical reasoning for wrist deformities

Wrist flexion = weak grip strength = unreliable grasp

Wrist extension = tenodesis = improved grip strength

Wrist splint considerations:

Wrist extension splint = increased tension to long finger flexors

Tightness of long finger and thumb flexors = night time resting hand splint

Wrist surgery pre-op evaluation

Does active finger movements improve as a result of wrist extension?

Trial wrist splint +/- thumb and reassess function

WRIST SURGERIES

1. Flexor to extensor
Eg. FCU to ECRB
2. Extensor to extensor
Eg. ECU to ECRB
3. Wrist fusion

FOREARM

FOREARM PRONATION

Pronated pattern = no bimanual opposition

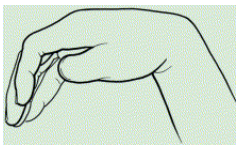
Supination wrap to achieve midline

FOREARM SURGERIES

1. Pronator teres reroutement
2. Pronator teres release

*Flexor to extensor FCU to ECRB has a supination moment

THUMB-IN-PALM



THUMB-IN-PALM

Thumb adductor spasticity = hyperextension at MCP

Reposition metacarpal into abduction to flex at MCP

THUMB SURGERIES

1. EPL re-routement extension to abduction
2. MCP fusion for collapse
3. Thumb adductor release

HOW TO PREPARE FOR SURGERY

- Need to support arm in an elevated position for swelling in bed and/or wheelchair
- Immobilization plan? Cast vs. splint. Fall precautions.
- What are the surgical precautions and for how long?
- When are they ready for active rehabilitation?
- Where will they get therapy in the community?

CASE EXAMPLE:

- Patient present with the common pattern of wrist flexion and hyperextension at the MCP's.
- Objects often slip due to unreliable grip (poor active assist).
- Thumb hyperextends at the MCP due to adductor spasticity and manipulates in a closed thumb position.

SUGGESTIONS FOR SPLINTING?

A. Wrist splint
B. Resting hand splint
C. Hand-based thumb splint
D. Thumb based MCP splint


A


B


C


D

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IMMOBILIZATION OPTIONS…


Hip Spica cast


Hip Spica splint

…IMMOBILIZATION OPTIONS…

Petri splint

Long leg splints

…IMMOBILIZATION OPTIONS

Long knee brace

WEIGHT BEARING INSTRUCTIONS

Non-weight bearing	Weight bearing as tolerated → Pain
Bony surgeries • Femoral osteotomy • Pelvic osteotomy • Calcaneal lengthening • Fusions	Muscle lengthening (adductors, hamstrings, gastrocs, TAL)
Tendon transfers (Tibialis posterior, rectus femoris)	Femoral Epiphysiodesis
	Botox

WHAT TO THINK ABOUT…

Baseline mobility, stairs, lifts/transfers, bed mobility, toileting

Sitting adaptations? ambulatory child?

Other equipment? crutches, walker.
Keep in mind coordination and upper extremity function

CASE

CASE 1

Patient

- 13 y.o male 5.4 ft. 130lb
- GMFCS II
- Autistic with aggressive behaviours related to pain and new situations.

Social

- Usually sleeps on a mattress on the floor because wonders around at nighttime.
- Single mom, only caregiver with 3 other children.

Home

- Has 3 steps to access the house
- One floor
- No adaptations since patient is ambulatory

Surgery

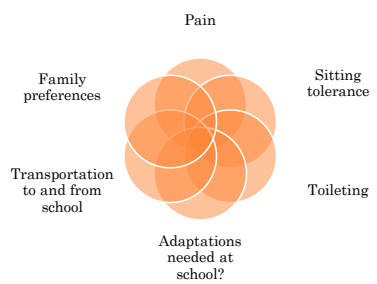
- Hamstring lengthening and anterior distal femoral epiphysiodesis.
- Long knee brace full time for 3 weeks.
- WBAT.

What equipment would you get for this patient?

EQUIPMENT




GRADUAL RETURN TO SCHOOL CONSIDERATIONS



Expectations for recovery- tips

- Full recovery usually takes between 6 to 12 months.
- A certain amount of pain and discomfort is to be expected, especially when introducing an activity for the first time after surgery.
- Usually patients experience increase pain and discomfort when changes in immobilization system occur (i.e. from Spica cast to Petri splint)
- Changes in GMFCS levels are not expected
- Family physicians are a good source for pain management.
- Use your professional intuition!

Expectations for recovery-Red flags

- Increased or constant pain not responding to treatment
- New or worse redness, warmness and/or swelling around the surgical site
- Fever
- Sudden inability to weight bear
- Intolerance for immobilization system

Questions?

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Contact us!

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