Objectives

- The participant will recognize the spectrum of Cerebral Palsy reflected in consensus definition and the current profile of Cerebral Palsy in Canada.
- The participant will learn how classification systems of motor function inform prognosis
- The participant will be familiar with recent guidelines for hip surveillance and bone density management in cerebral palsy
- The participant will recognize the growing role for robotics and virtual reality in rehabilitation and how emerging technologies aim to further improve motor function for individuals with cerebral palsy.

Epidemiology

- Largest single cause of childhood physical disability in the developed world
- Overall prevalence ~2-3.5/1000 live births
- Increased through 1970-1980's which paralleled trends in survival for premature and low birth weight infants
Cerebral Palsy: Definition

“Cerebral palsy 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...are often accompanied by disturbances of sensation, perception, cognition, communication, and behaviour, by epilepsy and by secondary musculoskeletal problems.”

The Definition and Classification of Cerebral Palsy. Dev Med Child Neurol. 2007 Feb;49(s109):1-44. PubMed PMID: 17371509

- Permanent disorders
- Movement and posture
- Activity limitation
- Non-progressive disturbance/injury
  - Secondary effects may be progressive
  - Effects of aging may lead to progressive functional impairment

- Sensation
  - Impaired stereognosis and 2 point discrimination in 40-50%
- Perception
  - Severe visual impairment in 20%
- Cognition
  - Learning disability in 40%
- Communication
  - Impaired in 40-80%
+ Behaviour
  + 5x risk of behaviour problems
+ Epilepsy
  + 30-40%
+ Secondary musculoskeletal problems
  + Torsional deformities, contractures, hip subluxation, foot deformities

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**GMFCS**

+ Gross Motor Function Classification System
+ 5 Levels of function based on gross motor function measure (GMFM) scores
+ Classification meant to represent current usual performance (rather than capability)
+ 5 Age bands – before age 2, 2-4 years, 4-6 years, 6-12 years, 12-18 years

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Severity by GMFCS Level

Stability of GMFCS
GMFM in Adolescence

- Longitudinal study of subjects from the Ontario Motor Growth study

[Graph showing data]


Drop in GMFM-66 score related to:

- Limited range of motion (hip, knee, ankle, upper extremity)
- Spinal alignment
- Pain
- Not necessarily reflected in participation
- Exercise participation low overall


Locomotion Skills

- Retrospective survey of adults with cerebral palsy
- 27% reported improvement in walking skills over time
  - Primarily before age 25
  - 28% no change
- 44% reported deterioration
  - 10% had lost their walking skills

Locomotion Skills

- Self-reported causes of deterioration
  - Pain
  - Fatigue
  - Lack of adapted physical activity
  - Deterioration strongly associated with
    - Older age
    - Delayed walking debut
    - Severe neurological impairment


Gait deterioration may occur in two peaks

- Adolescence/young adult
  - Progressive crouch gait
  - Inability to keep up with peers
- Age 40-45
  - Progressive fatigue
  - Pain
  - Joint deterioration
  - Lower risk of deterioration in highest functioning groups


The Hip in Cerebral Palsy

- Estimated frequency of hip displacement in cerebral palsy 2-75%
- Etiology
  - Spasticity and/or contractures of hip flexors and adductors, and medial hamstrings
  - Osseous deformities due to lack of weightbearing: femoral anteverision, acetabular dysplasia
Hip displacement defined by migration percentage:
percentage of femoral head lateral to Perkin's Line

- >30% = subluxed
- >100% = dislocated
- Also known as migration index/Reimer’s index

Fig. 30-10  Subluxated left hip joint. Migration index (MI) is calculated by dividing width of uncovered femoral
head A by total width of femoral head B. Acetabular is dysplastic (type 2 sourcil), with lateral corner of
acetabulum above weight bearing dome. Normal hip (left side) with acetabular index (AI) indicated. There is
normal type 1 sourcil, lateral corner in deep and below weight bearing dome. (From Flynn JM, Miller F: Management of
Incidence of hip “displacement” (MP >30%) directly related to GMFCS level (overall 35%)

**Management of the Subluxed Hip**

- Migration percentage
  - >20% - consider Botox and/or phenol, adductor and/or psoas and/or medial hamstring release/lengthening
  - >40% - will progress to dislocation. Requires bony procedures (femoral derotation osteotomy +/- varus osteotomy +/- acetabular procedure)

**Consequences of Hip Dislocation**

- Lever arm dysfunction (interference with gait)
- Pain
- Difficulty with seating/positioning
- Interference with self-care
Hip – All Levels

- Refer to an orthopedic surgeon if:
  - MP is unstable (>10% change in 12 months) and/or progresses to >30%
  - There is pain related to the hip

Hip – All Levels

- Initial AP pelvis radiograph at 12-24 months (or initial diagnosis if older than 24 months)
- Repeat radiographs if hip subluxation or dislocation clinically suspected
  - Pain
  - New leg length discrepancy
  - Marked change in hip range of motion
Hip – GMFCS I

- Repeat clinical assessment at age 3 and 5
- If classification of GMFCS I remains unchanged there is no need for further surveillance

Hip - GMFCS II

- Repeat radiographs annually until migration percentage (MP) stabilizes
- If MP is stable review at 4-5 years and 8-10 years
- If MP is increasing continue with annual radiographs

Hip – GMFCS III

- Repeat radiographs every 6 months until MP stabilizes
- Once MP is stable reduce radiograph frequency to every 12 months
- Review at 7 years
  - If MP is stable and <30% may discontinue radiographs until pre-puberty
  - Resume annual radiographs at pre-puberty and continue to skeletal maturity
Hip – GMFCS IV

- Same as for GMFCS III
- If scoliosis or pelvic obliquity is present maintain 6 monthly radiographs until skeletal maturity

Hip – GMFCS V

- 6 monthly radiographs
- At 7 years if MP is stable and <30% reduce frequency to every 12 months until skeletal maturity
- If scoliosis or pelvic obliquity is present maintain 6 monthly frequency

BMD, Fractures and CP

- Children with cerebral palsy are known to have low BMD compared with controls
- Fragility fractures
  - Incidence 7-10% in severe CP
  - Prevalence up to 20% in non-ambulatory children and adults with CP
  - Most common site is distal femur

Risk Factors for Low BMD and Fractures

- GMFCS level
- Decreased weight bearing
- Anticonvulsant use
- Poor nutrition
- Decreased exposure to sunlight

Controversies Surrounding BMD in CP

- When and how to measure BMD
- How to use the information
- When to incorporate Vitamin D, Calcium and Bisphosphonates
- Role of weight bearing in prevention and/or management of low BMD

Evidence – Weight Bearing

- 6 studies using various modalities with conflicting results
- Fracture rates not evaluated
- No adverse events

- Recommendation: Further studies are required but given other benefits of weight bearing a physiotherapy consult is recommended
Evidence – Vitamin D and Calcium

+ Level C evidence (possibly effective) for increasing BMD
+ BMD increases of 4-24%
+ Insufficient evidence for decreasing fragility fractures
+ No information on fracture rates

**Recommendation:** Review daily calcium intake and supplement if required; Consider starting Vitamin D; Baseline bloodwork with repeat at 6-12 months

### Technology and Cerebral Palsy

- Motor development is enhanced through intensive therapy especially during periods of rapid growth and after surgery to manage secondary orthopedic impairments or spasticity
- The success of a rehabilitation program is dependent on:
  - The intensity of therapy
  - Repetition
  - Goal-oriented, task-specific
  - Motivation and active participation

### Technology and Cerebral Palsy

- Conventional therapy programs are personnel intensive and expensive
- Limited resources often prevent achieving optimal therapy conditions
- Robot assistance and virtually reality systems could allow for:
  - Reduced personnel needs
  - Increased repetition and frequency of therapy
  - Improved motivation and active participation

### Robot Assisted Gait Training (RAGT)

- Lokomat
  - Degree of assistance can be customized
  - Visual real-time feedback of effort
Robot Assisted Gait Training (RAGT)

- Improvements found in:
  - Gait velocity and endurance
  - Standing and walking dimensions on the gross motor function measure (GMFM)
- Possible improvements in:
  - Balance
  - Spasticity


Robot Assisted Gait Training (RAGT)

- Motivation generally remained high during therapies
- May be better than conventional gait training for individuals with severe cognitive impairments
- GMFCS level I and II may benefit more than III and IV


Virtual Reality Systems

- Can be integrated into RAGT with further improvement in motivation and active participation

CAREN
Computer Assisted Rehabilitation ENvironment

Xbox Kinect

