1. Why do we think that an aging adult with a mild first time stroke has a better outlook for recovery than a baby with a similar mild stroke?
We now know that baby brains have more recovery potential than adult brains, but our models of service delivery are still based on a pre-neuroplasticity concept of “no hope of a cure” for children with cerebral palsy. There is a clear difference in the acceptance of neuroplasticity at the level of the National Institutes of Health in the USA. Up to 30% of adults with a mild, first time stroke may have a complete recovery. This is reflected in this quote from the Stroke information page.
“New advances in imaging and rehabilitation have shown that the brain can compensate for function lost as a result of stroke.”
The contrast between this and the prognosis on the CP information page is stark.
“Cerebral palsy can’t be cured, but treatment will often improve a child’s capabilities.”

2. Baby brains have a greater potential for regrowth, repair, reorganization and reallocation of brain resources than do adult brains.
The amount of recovery potential depends upon the age of the child at the time of injury and the amount of remaining normal brain. Early hemispherectomy patients demonstrate just how much functional recovery is possible. This brain scan is of an anatomical hemispherectomy performed on a 3 year old girl with Rasmussen’s Encephalitis. Four years post-op her only motor defect was minimal tightness in her right hand and she was fluently bilingual in 2 languages in spite of losing her left hemisphere.

Neonatologists know that some children with major early brain lesions also recover.
In one study of 214 children of < 36 weeks’ gestation, 86% of those with a Grade III and 45% of those with a Grade IV bleed had a normal motor and cognitive outcome at 2 years corrected age.


3. The baby brain grows and matures throughout childhood into young adult life.
MRI studies have demonstrated that female brains achieve maturity at 20-25 years, male brains at 30-35 years. However, growth is not linear. There are 2 peak periods of growth and maturation: from birth to 4-6 years and another 4-6 years in puberty. Girls enter puberty an average of 2 years ahead of boys.

4. Lesion specific therapy interventions are not currently aligned with periods of peak brain growth.
Traditional thinking was that a confident diagnosis of cerebral palsy could only be made between ages 3 to 6 years. The families of children at risk of cerebral palsy were, and often still are, counseled to “wait and see”, delaying diagnosis and access to lesion specific therapy. This is an outdated, incorrect approach as there are now well validated early assessments that add to the diagnostic accuracy of brain scans in infancy.


Most lesion specific therapy is concentrated between the ages of 4 to 12 years. By the early teen years, the expected functional gains have plateaued. Most are then discharged to school therapy. They are now considered to be “too late to change”.

This common delivery of care model completely misses the 2 peak periods of brain growth, wasting the neuroplastic potential of lesion specific motor and cognitive interventions.

**Peak Periods of Neuroplasticity vs Period of Maximal Therapy**
5. Lesion specific therapy interventions are not currently aligned with periods of peak body growth.

Body growth continues through the teenage years with 2 peak periods of growth velocity. The infant grows to half their expected adult height by age 2-4 years. The second peak growth velocity period is during puberty. Again, our common service delivery model misses these 2 periods of ballistic growth.

**Peak Periods of Body Growth vs Peak Growth Velocity**

6. Brain and body growth interact to create the clinical syndrome of motor disability in cerebral palsy.

In clinical registry data, 80% of all children with a diagnosis of cerebral palsy have spasticity. The severity of spasticity increases throughout the growth cycles until the child reaches bony maturity. Throughout all this time, with each growth spurt, the tone tightens. *This is an unexpected finding. If the brain is growing and maturing, why is the body deteriorating?*

It is well recognized that there is progressive body distortion with untreated spasticity. Treatment of this distortion, by correcting malalignment, predictably leads to a reduction of tone. *This is another unexpected finding. Surgery brings the muscles, tendons and bones back into alignment and Orthopedic surgeons take great care to not damage nerves during surgery. Why then does spasticity decrease?*

From Gillette’s Children’s Hospital pre and post SEM
7. **A New theory and clinical approach to spasticity is needed.**
Spasticity increases as the child grows, at the same time as the brain is growing and maturing. There is a continuous feedback between the brain and body. The early abnormal signals from the damaged baby brain cause an unequal activation of the muscle groups. In the most common forms, the flexor muscles of the upper limbs and the extensor muscles of the trunk and legs are preferentially activated. This abnormal activation causes an unequal growth pattern that ultimately affects body alignment. Each time the spastic muscles contract they contribute to this malalignment. Growth makes it worse, gradually producing body distortion. As the child moves against gravity, typical patterns of abnormal movement are perpetuated. Walking badly does not improve function, it teaches the child to do badly better.

8. **Spasticity becomes a self perpetuating habit**
Each of the commonly used neurorehabilitation techniques in our collective toolboxes work at some point in the negative feedback loop of spasticity. It is important to figure out what each technique adds to the rehabilitation program. No one technique will do all the work that is needed. The purpose of this workshop is to provide a model of using the right thing, at the right time and in the right order. Step one is uncovering recovery hidden by habit.

9. **A New way of seeing is needed.**
Doctors and therapists are taught to look for what is “wrong” with a movement pattern. The typical, atypical movement patterns of hemiplegia, diplegia, and quadriplegia are what we see. These are habitual movement patterns that ultimately produce abnormal growth. Breaking the spasticity habit cycle requires us first to make a conscious effort to “see” the best higher order function.
What do you see?

Roughly 50% of us will first see the image of an old lady, while the rest will be sure it shows an image of a young lady. There are many commonly used perception slides that all make the point that our brains are wired to see what we expect to see and to largely ignore what we do not expect to see. This basic brain “fault” explains why it is so hard for us to recognize the signs of brain recovery in children with early brain injury.

10. **The Boy Who Could Run But Not Walk: Understanding neuroplasticity in the child’s brain.**
The book, of the same name, describes KP’s journey of understanding that led to the concept of Habit Hides Recovery. It started with one mother’s insistence that her boy with spastic diplegia was able to play age appropriate competitive soccer. My initial response to her was disbelief. I had to see it for myself! Once I started to look for examples of higher order function, they were
everywhere. We all see it, but our focus remains on trying to correct the early acquired abnormal habits.

**Video Case Studies**

1. **Walk/Run**
   
   I have learned that all children with Hemiplegia run better than they walk. The walk is abnormal but same child’s running pattern is his best gross motor function. These different levels of motor skill use the same parts of the brain, learned at different ages and stages of development. The children create two separate motor movement patterns. The early walk was learned with a damaged brain in the process of recovery and maturation. The early acquired abnormal gait is a habit and it will not change unless we apply neuroplastic principles that include novel purposeful practice done intensively. The later running skills were learned with a more mature brain after the early 3-4 year recovery period.

2. **Walking Forward and Backwards**
   
   You can also demonstrate this disconnect between habit and actual brain potential by asking the child to walk backwards. This is a novel task that challenges the brain out of habit to reveal the underlying brain potential.

3. **Out of Gravity**
   
   Another way to demonstrate brain potential is to take the child out of gravity using a neutral buoyancy device like the wet vest. The jogging pattern is often a perfect 4-point reciprocal movement pattern. There is a similar improvement in a child’s gait pattern using a gravity reducing support on a treadmill when compared to walking over ground.

   We have to understand that just because we can prove that a child can do a higher order function does not mean that they will automatically do it. Changing habits is hard. Whether you’re doing above ground gait training or out of gravity gait training, what is required is practice, practice practice.

   "Practice does not make perfect, perfect practice makes perfect"

   Vince Lombardi

11. Most children with cerebral palsy walk. The question is not if they will walk, but how well will they walk?

The incidence and severity of cerebral palsy has changed dramatically in the last 40 years. 80% of children are GMFCS Level I to III, 60% walk independently. Novak, I: Evidence-Based Diagnosis, Health Care, and Rehabilitation for Children With Cerebral Palsy. Journal of Child Neurology 2014; 29: p1141-1156

These are the results of the pre-neuroplasticity neurorehabilitation service model in place in 1996-2001. The results show that the majority of gains in GM development, to 90% of expected motor ability, occur in the first years of life. After these early years, the curves flatten out and remain stable for those in Levels I and II. There is a consistent decrease in functional levels with pubertal growth in those at Levels II, IV and V. These are the results of the pre-neuroplasticity neurorehabilitation service model in place in 1996 -2001. Can this dismal outcome information be improved? Yes, but only if current evidenced-based and best practice therapies along with medical and surgical interventions are used at the right time and in the right order. Sarah McIntyre et al, “Cerebral palsy-don’t delay”, Developmental Disabilities Research Reviews, 17 (2011): 114–129. Iona Novak et al., “A systematic review of interventions for children with cerebral palsy: state of the evidence”, Developmental Medicine & Child Neurology, 55 (2013): 885-910. Changing the outcome for children with cerebral palsy starts with four principles:

- Alignment
- Awareness
- Activation
- Strengthening

After the break, Pia Stampe, PT, DPT and Suzanne Davis, PT, C/NDT Coordinator-Instructor will present their approaches to achieving these goals with case studies demonstrating rapid change with intensive interventions.

A complete bibliography will be available for download after the presentation.
Habitual Gait / Movement Patterns

1. Alignment
   - • Spasticity Management
   - • Surgery
   - • Other
   - • Specialists
   - Good

2. Awareness
   - • Sensory Vibration
   - • Mirror
   - • Squeaky Shoes
   - • EMG Biofeedback
   - • Etc.
   - Good

3. Activation
   - • Facilitation Techniques
   - • EMG Biofeedback
   - • ETS
   - • NMES
   - • NMES
   - • Etc.
   - Good

4. Strength
   - • Train in Alignment
   - • Pool
   - • Cage
   - • Treadmill
   - • Close kinetic chain
   - • Circuit training
   - • Etc.
   - Good

Best Performance

If Not Good
- Change with:
  - • Theratog
  - • Spio
  - • DMO/Protec
  - • AFO
  - • Splints
  - • Soft Tissue techniques
  - • Stretching
  - • Etc.

If Not Good
- Sensory
  - • Vibration
  - • Mirror
  - • Squeaky Shoes
  - • EMG Biofeedback
  - • Etc.

If Not Good
- Facilitation
  - • EMG Biofeedback
  - • ETS
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If Not Good
- Spasticity Management
  - • Surgery
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  - Etc.