



**Children's**  
**Cerebral Palsy**  
**Movement**  
A DIAGNOSIS, NOT A DESTINY

Introducing  
“Neuroplasticity and Exercise  
in an  
Enriched Environment”  
-Dr. Sofia Sawitz, DPT

# Welcome...



The following presentation provides information found in the literature that:

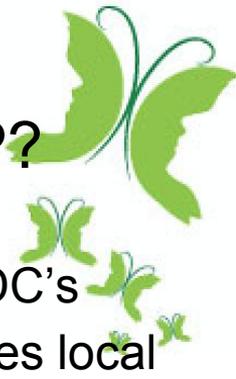
- expresses a need for **research funding** for those diagnosed with Cerebral Palsy
- explains the effects found and theorized from participating in exercise with an **enriched environment**: music, group exercise, dance.
- explains specific components that generate **neuroplasticity** in both animal studies, normal subjects, and in subjects with neurologic diagnoses.

# What do we know about brain injuries in adults?



- There are stroke rehab protocols for adults who have strokes.
- Roughly **\$300,000,000** is dedicated annually for stroke research. Thus, it has become general knowledge that with intensive physical therapy an injured adult brain can recover lost function both acutely and years after injury.
  - This was not the case 20 years ago.
- Several therapies have evolved from extensive stroke based research:
  - Mirror Therapy
  - Constraint-Induced Therapy
  - Virtual Therapy

# What do we know about the research in children with CP?



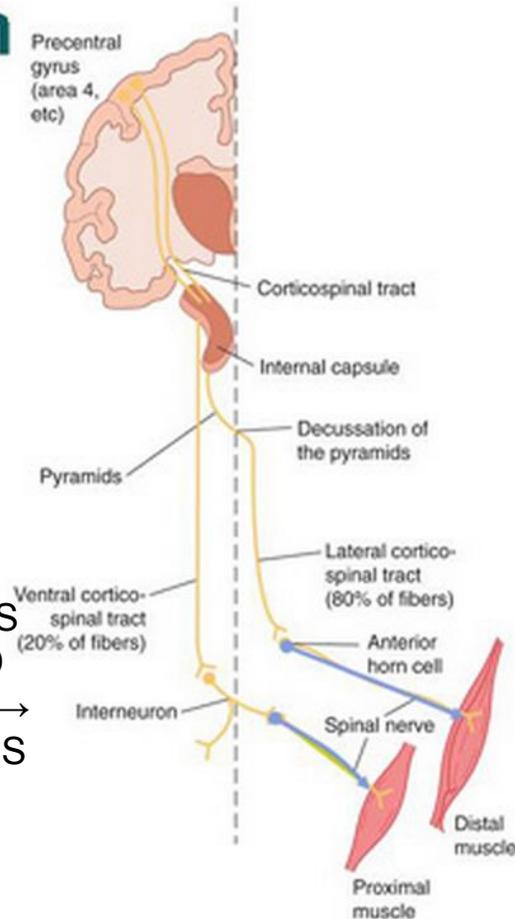
- Although there are programs such as the *Brain Initiative* at NIH and CDC's research into birth defects and developmental disabilities, which includes local surveillance of CP in four sites as part of the ADDM Network, there is **no dedicated U.S. line item federal funding for Cerebral Palsy research at the CDC or NIH**, even though Cerebral Palsy has higher prevalence than muscular dystrophy, Parkinson's disease, childhood cancer, hearing loss, spina bifida, hemophilia, fetal alcohol syndrome, or cystic fibrosis.
- More research would mean the possibility of ***prevention and earlier diagnosis***, more ***effective treatment*** options, and eventually the possibility of a ***cure***.

# What can the literature tell us about neuroplastic capabilities in Cerebral Palsy?



- What do we know about the corticospinal pathway organization in someone with hemiplegic CP who has had mirror therapy?
  - In subjects with hemiplegic cerebral palsy, Carr et al 1993, used focal magnetic stimulation of the motor cortex and digital nerve stimulation to follow reflex pathways and to investigate the corticospinal projections from both the injured and normal sides of the motor cortex in subjects who were randomized into a control group and an intensive mirror therapy group. Cross correlation analysis of multi-unit EMG's were also used to detect activity in the spinal cord for motor input. They found that the motor cortex on the **normal side of the brain sent projections at the level of the spinal cord to the ipsilateral, hemiplegic limb after intense mirror therapy with improved clinical outcomes.**
- The view that Cerebral Palsy is a static condition must be questioned.

# Upper Motor and Lower Motor Neuron



Carr et al 1993 HIGHLIGHT THIS LEVEL OF THE SPINAL CORD AT THE INTERNEURON → FOUND TO SEND PROJECTIONS BACK TO AID THE INVOLVED HEMI-PARETIC LIMB.

Figure 11-5. In: Barrett KE, Barman SM, Boitano S, Brooks H. *Ganong's Review of Medical Physiology*. 23<sup>rd</sup> ed. <http://www.accesspharmacy.com>. Accessed October 29, 2009.

# How does neuroplasticity science inform us about optimal exercise program designs?

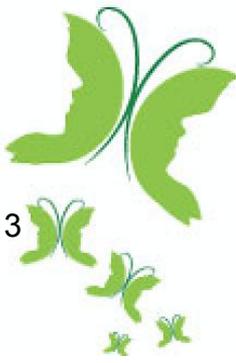


- Driving brain plasticity with positive outcomes requires:
  - demanding **sensory, cognitive, and motor activities** on an **intensive** basis, in a **behavioral context** designed to **engage and strengthen** the neuromodulatory systems that control learning in children, with the goal of increasing the representation, reliability, and power of cortical pathways.
- To create the neuroplastic recovery needed to improve the function in children with CP: (high repetition, attention, motivation, consistency), there is a basic need for an **enriched environment** to maintain patient adherence to the exercise.



## Benefits of Aerobic exercise.

- Aerobic Exercise has shown to have a neuroprotective effect and reduces the risk of:
  - Dementia<sup>2,3,4,5</sup>, Parkinson's Disease<sup>6</sup> (PD), & Stroke<sup>7</sup>
  
- Some studies do show improvements in physical & functional impairments in:
  - Dementia<sup>8,9</sup>, Parkinson's Disease<sup>10,11</sup>, & Stroke<sup>12</sup>



## Other Benefits of Exercise from the research:

- **Neurogenesis** in the dentate gyrus of the hippocampus: Animal study<sup>13</sup>
- **Increased cognition** (learning and memory)<sup>14</sup>
- **Angiogenesis** throughout brain: hippocampus, motor cortex, and cerebellum<sup>15,16,17,18,19</sup>
- **Neurotrophic Factors** are upregulated following exercise treatments which promote plasticity<sup>20,21</sup>:
  - Insulin-like growth factor
  - Fibroblast growth factor 2
  - Brain Derived Neurotrophic factors (BDNF's): have a role in neural reorganization & regeneration in a compromised nervous system
    - Crucial role in hippocampal learning and memory formation
    - Neuroprotection & promotion of cell survival
    - recovery of motor function
      - All of these are aspects needed for neuroplasticity on a chemical level.



# Improvements in Function With the Help of Music

- Huge Paradigm shift in late 1990's with the discovery of Auditory-Motor Pathway (via reticulospinal connections).<sup>22,23</sup>
- Rhythmic Auditory Stimulation (RAS) has led to functional improvements in those with brain injuries:
  - Gait: stride length, step length, cadence, & velocity<sup>24</sup>
  - Upper Extremity function<sup>25</sup>
  - Executive function<sup>26</sup>
  - Speech (in non-fluent aphasics via Melodic Intonation Therapy)<sup>27</sup>
- **Priming Effect**-> Music influences the threshold excitability of motor neurons creating a readiness on the segmental motor system.<sup>28</sup>
- Priming effect functionally facilitates a timing effect of **muscle activation patterns** during auditory rhythmic cuing of rhythmic leg movements.<sup>28</sup>

# Music- Priming Effect in Stroke



- Thaut et. al 1993<sup>28</sup>, subjects 6-18 months post stroke, trained their gait to rhythms
- Found improvements in gait via rhythmic cuing:
  - Velocity, step cadence, swing symmetry
  - EMG Variability of the gastroc muscle reduced significantly in paretic limb, therefore more efficient **muscle recruitment**.
- Grau-Sanchez et. al 2013<sup>29</sup>, TMS to evaluate different behavioral motor test that were tested pre- & post- music therapy
- Found significant motor improvements in the paretic hand & those changes were accompanied by neuroplastic changes in the motor cortex
  - **JUST THE ACT OF LISTENING TO ENJOYABLE MUSIC ENHANCES RECOVERY!!**

# Music Enhances Participation



- Music enhances participation in exercise due to the:
- Decreased **perceived difficulty and discomfort** associated with physical activity<sup>30,31</sup>

# Dance, Cognition, and Neurologic Structures



- Dance is a physical and cognitive activity in an enriched environment and therefore the perfect recipe for neuroplasticity.<sup>32,33,34,35</sup>
- Activates various cognitive functions: perception, emotion, executive function, and motor skills.<sup>36</sup>
- Creates<sup>37</sup>:
  - multi-sensory experience
  - in and engaging environment
  - incorporates: music listening, physical activity, and social environment.
- Expert dancers have neurologic structural differences: sensorimotor network and hippocampus<sup>38,39</sup>

# Recap of Animal Studies... How does this relate to Dance?



- **Exercise** induces neurogenesis via increasing precursor cell proliferation<sup>40</sup>
- **Enriched environments** induce neurogenesis by promoting the survival of new cells<sup>40,41</sup>
- Theorized: Exercise may increase the precursor cell pool but cognitive stimulation may increase the ability of the cells to be integrated into functional networks in humans.<sup>42</sup>

## Animal Studies cont...



- Curlik et. al 2011<sup>43</sup>, 3 groups: sedentary, exercise wheel, or walk on rotating rod that rotated with increasing velocity in rats who learned how to navigate it.
- Rats in rod group retained more neurons in their hippocampus despite exercise group running 20 times the distance of learning group
- Survival rate of the neurons was found to be similar in the exercising and sedentary group.
- Could demonstrate long lasting effects on adult brains because it combines the mental & physical challenge of novel skill training.
- Ballet = mental and physical challenges

# Established Evidence on Dance in Adults...



- In older adults dance improves:
  - Balance, postural control, endurance, and motor performance<sup>44-50</sup>
- Parkinson's population shows a significant improvement in:
  - Balance, gait, rigidity, upper extremity functions, and functional mobility<sup>50-53</sup>
- Stroke:
  - Hackney et al 2012, patients with chronic stroke, case study on patients who danced tango noted increase in balance, mobility, and endurance.<sup>55</sup>
- Overall: Dance research is still in it's infancy in area of functional improvements.

# Social Environment Effects When Exercising...



- Social Isolation during running exercise suppresses neurogenesis<sup>56</sup>
- Walking with others activates more widespread network in the brain than walking alone<sup>57</sup>
- Group-based exercises have been reported to possess higher participation rates<sup>58</sup>
- The act of developing social relationships is associated with the enjoyment of an exercise<sup>59</sup>

# Exercise Environment and Adherence



- Estimated over 50% of participants who start an exercise program will stop within 6 months<sup>60</sup>
- In neurologic population, it is important that the therapy implemented:
  - Promotes continued commitment that is part of the person's weekly routine
- Important factors that affect adherence<sup>60</sup>:
  - social support
  - health
  - personal beliefs
  - motivation
  - enjoyment

## Works Cited



Please see website for complete list of cited literature.