Objectives

- Name some different forms and techniques of electrical stimulation used in the clinic, and cite one study related to NMES (Functional Electrical Stimulation) and Whole Body Vibration (WBV).
- Understand the reasoning behind the choice of equipment and technique used for using FES and WBV in the pediatric population as compared to adults.
- Cite the indications, precautions, and contraindications of NMES/FES.
- Discuss the basics of motor control as it applies to enhancement through use of FES and WBV.
- Cite one example of effective electrode placement for treatment when using FES using a single or multiple units.
- Name and select various treatment positions and exercises when using WBV to improve strength, balance, muscle power, and bone density.

Let’s talk about electrical stimulation: How many pediatric therapists use electrical stimulation for their patients?

- At APTA CSM 2015 in Boston, this question was asked in a room of approximately 300 therapists. 4 raised their hands. Has significantly improved since then.
- How are you using electrical stimulation with your pediatric patients? NMES? FES? Sensory level? Eliciting a strong contraction?
- Is it working for you as well as you want? How about long-term outcomes?
- Can you say that the children you are seeing show true motor learning?
- WHY is using electrical stimulation so hard for therapists to incorporate into treatment?

Barriers to FES Use

- Preference to use other treatment options (52%)
- Lack of training in FES (40.2%)
- Patients not having access to a device in their home (68.1%)

* 64.9% stated that hands on training would increase their use of FES, with 52.7% stated they would like to increase their use of FES in clinical practice.

Facilitators of FES Use

- Access to resources (time, equipment, funds, support from colleagues and supervisors)
- ADEQUATE TIME was as important as equipment in working order, simple set up
- Support from colleagues in leadership positions
- Creative support in the workplace (regular FES group sessions)
- Working with colleagues
- FES suppliers who are knowledgeable and responsive to questions.
- Patients having access to funding for device for home use
My thoughts on another type of barrier:

- Students are taught Electrical Stimulation (NMES and FES) as a modality, instead of being paired with therapeutic exercise. Why?
- FES is a MOTOR SKILL, on the part of the therapist, which requires practice to become proficient. Hours and hours of practice.
- Practice makes perfect! It should be as automatic as riding a bike.

And finally, the “literature” causes therapists, especially pediatric therapists, to doubt their knowledge:

- Inaccurate, and just wrong, terms are actually printed on the equipment?
- NMES, FES, ES, TES, TASES? Why so many names? And which one do I look for in the literature? If I should know this—maybe I missed it when they talked about it in school?
- No accepted standards for treatment: Settings vary widely from one study to another. How is a therapist who is just starting out to know what to follow?
- By necessity, research must have a start and end point (usually 1 week to 16 weeks in pediatric literature). Is it enough time for motor learning to occur, or to actually get permanent change? And if you cannot get permanent change, what is the point of doing it at all?

What is a therapist to do?

Confusion sets in:

“I give up… I can’t take any more!!!!”

What is Neuromuscular Electrical Stimulation (NMES)?

NMES is the application of an electrical of sufficient current intensity to elicit a muscle (fiber) contraction. Two electrodes are placed on the skin overlying the target muscles. Contraction occurs through the stimulation of the intramuscular branches of the nerve supplying the muscle. Direct stimulation to the nerve activates both sensory and motor fibers.

Definition of Functional Electrical Stimulation

Functional electrical stimulation (FES) is the application of electrical current to excitable tissue to supplement or replace function that is lost in neurologically impaired individuals.

Or....stated another way:

The application of an electrical current to a muscle or nerve to improve a sensory and/or motor deficit due to a previous injury to the nervous system. The purpose of functional electrical stimulation is to augment (through the sensory and the motor system) a functional movement or a task that the child wants to accomplish. The child’s desire to accomplish the task is key for motor learning to occur.

For pediatrics, Gad Alon simplifies it:

• Some electrical stimulation (NMES) is better than no electrical stimulation.
• More electrical stimulation is better than some electrical stimulation.
• My observation: Functional electrical stimulation is superior to passive electrical stimulation cycling on and off (NMES).
• That does not mean you do not use it if you cannot do functional electrical stimulation. It is possible get a positive response if you just use NMES! This is a win/win for you and the child/parents!

Voluntary Muscle Activation, Contractile Properties, and Fatigability IN Children With AND Without Cerebral Palsy


Because children with CP demonstrated large deficits in voluntary muscle activation, using voluntary contractions for strength training may not be sufficient to induce muscle hypertrophy. Techniques such as enhanced feedback and neuromuscular electrical stimulation may be helpful for strengthening muscles that cannot be sufficiently recruited with voluntary effort.

“Electrical stimulation speaks the language of the nervous system”

Edelle Field-Fote, CAPTA 2011 Annual Conference, Oakland, CA

• Giving a pre-synaptic cell electrical stimulation at baseline, coupled with a meaningful functional activity, will give a larger response.
• “Spasticity” has a lower response to normal input, but if we depolarize, the muscle is able to fire.
• “Response improved over time”!!

“Spastic Muscles”

Edelle Field-Fote, 2011

• “Spastic” muscles have a resting membrane potential lower than non-spastic muscles
• They are in a depressed state and require more input to be excited for chemical changes to begin
• ES helps chemically excite the neuron, so that it is more easily recruited

Impairments in Children with CP

Spasticity (more about this when we discuss motor control):

• Decreased range of motion (ROM)
• Both increased and decreased muscle tone
• Decreased strength
• Decreased motor control
• Decreased balance
• Decreased endurance
**SURGERY GOALS in Cerebral Palsy**

- Prevention of deformity
- Correction of deformity
- Promotion of a base of support
- Facilitation of training skills
- Improvement in the efficiency of gait

*Is it possible to accomplish these goals without surgery or other invasive procedures?*

**Most Common Interventions to Address “Spasticity” in Cerebral Palsy**

- Botulinum Toxin
- Medications (oral and surgically implanted)
- Surgical (orthopedic and selective dorsal rhizotomies)
- Serial casting
- Strengthening, including using electrical stimulation
- Balance training
- Endurance training

**How Do PT’s Prioritize Treatment… Thoughts?**

- Get rid of the spasticity and they will be able to move normally? (SDR’s, Botox, surgeries)
- Give patients more ROM and they will be able to move normally? (surgeries, serial casting, Botox)
- Increase strength and balance, and they will be able to move normally? (Strengthening, electrical stimulation, WBV)

**Physical Therapy Treatment Recommendations and Priorities - Are You Achieving Your Goals?**

- Increase strength (resistance, electrical stimulation)
- More ROM (orthopedic surgery, Botox, stretching splints, serial casting, electrical stimulation)
- Decrease, or get rid of, spasticity (BTX, SDR, medication)
- Functional movement where the child is free to participate in his/her life?
- Increase balance

**Children with cerebral palsy need to develop motor control!!**

**Equipment Precautions**

**Electrical Stimulation Units for Pediatrics, What Is Needed:**

- EMPI Continuum, the only one available that:
  1. Automatically turns off if the electrode comes loose.
  2. Is able to be programmable to switch from one channel to the other automatically necessary for gait or fast movement.
  3. Allows you to program in the child’s unique parameters.

**Electrical Stimulation**

- Do not place electrodes over the heart or throat (carotid sinus area).
- Do not use with an implanted device cardiac pacemaker, pacemaker, or deep brain stimulator.
- Do not use on a woman who may be pregnant.
- Do not apply to cancerous tissue.

[http://faculty.uca.edu/fletcher/electrom/1_TENS/Contraindications%20%26%20Precautions.pdf](http://faculty.uca.edu/fletcher/electrom/1_TENS/Contraindications%20%26%20Precautions.pdf)
Electricity is the Language of Neurons

- Electricity becomes feelings
- Electricity becomes movement

The brain likes patterns and wants to predict what comes next using all our senses:

- Hearing
- Seeing
- Moving

Since Electrical Stimulation Speaks the Language of the Nervous System...

**AND** the Brain's Preference is to Predict What Comes Next...

Multiple units give the brain more sensory and motor information for use to predict a pattern, by stimulating many muscle groups during functional electrical stimulation.

Hebbian Theory

- Neurons that **fire together**, wire together.
- Neurons that **fail to link** are out of sync.
- An increase in **synaptic efficacy** arises from the presynaptic cell's repeated and persistent stimulation of the postsynaptic cell.

10 Principles of Motor Learning (Kleim, JA, Jones, TA, 2008)

1. Use it or lose it.
2. Use it and improve it.
3. Plasticity is experience specific.
4. Repetition matters.
5. Intensity matters.
6. Time matters.
7. Salience matters.
8. Age matters.
9. Transfer is possible.
10. Interference can occur.

Child with cerebral palsy, diplegia with FES bilaterally to gluteals and gastrocs. He explains its effects on his body.

Child with cerebral palsy, right hemi-dystonia with FES bilaterally to the latissimus muscles.
Theory: The main problem to address in CP is not spasticity, but lack of motor control and motor learning!

No knowledge of the typical or "normal" movement patterns!

Progression of Walking

28 months after 9 months of 2x/week FES

From the first visit to the Dr., surgery was discussed, since everyone knew where he was headed.

Casey 9/2015 at Age 9

No surgery, not Botox, no medications.

Due to growth, he should look like this:

One year later (2014)…motor control is still improving. “Neurons that fire together, wire together.”

How Can PT’s Effect Change and Allow Motor Learning to Occur?

February, 2013

He has no problem in braces, but barefooted is difficult. He is walking his preferred walking vs trying to walk with heels down.
Walking barefoot 2.5 years later (age 11):

Progression of Hopping
Age 4
Age 5

Progression of Hopping
Age 9

Stepping up on a high surface
Left leg (harder side)
Right leg

1/2014 Continued Improvement:

9/15 Continued improvement:
Continued improvement in balance and motor control:


Participation....

Dylan (1/14/2014) could only walk .3 mph on the treadmill.

December 2015
End of Sessions—spontaneously caught him watching video games as I was talking to Mom.

7 months after starting FES  10 months after starting FES

Part of daily home program—stands to play on computer while doing NMES to multiple muscles.

11 Months Later

The Child’s Perspective

Participating!

Even More Participation…
Can go up and down stairs without help.

Peds Quality of Life Assessment (DW)
Total Score Improvement from 174 to 500

- How your child feels about using parts of their body, not whether they can use part of their body
- How your child feels about their ability to complete daily activities, not whether they can complete daily activities.
- How do you think your child feels about? (equipment)
- The next few questions ask about things that may bother your child.
- Some final questions about your child?
- Access to Services - How do you feel about?

Trying to hit the ball (1 year later):
Wanting to hit the volley ball to being able to hit the volley ball over the net

Talking about the ADDUCTORS

Do the hamstrings and the adductors contribute to excessive internal rotation of the hip in persons with cerebral palsy? (Arnold, Asajawam, & Delp, 2000)

- “Analysis of the models revealed that the medial hamstrings, adductor brevis, and gracilis had a negligible OR externally rotation moment arms throughout the gait cycle…”
- The adductor longus had an internal rotation moment arm, but the moment arm was small.
- “These findings indicate that neither the medial hamstrings, nor the adductor brevis, adductor longus, or gracilis are likely to be important contributors to excessive internal rotation of the hip. This suggests that these muscles should not be lengthened to treat excessive internal rotation of the hip and that other factors are more likely to cause internally-rotated gait in these patients.”

Prediction of ACL Injury: Landing with Knees Adducted
Why use FES for adductors in standing?

Short-term immediate changes that in the clinic:

- You will see change right away, but the child will need to practice in alignment (requires hands on treatment) to effect motor change over time.

Problem: Fisting

- 2 year old child with spastic quadriplegia, Level V. On medication to try to relax elbow/wrist/finger flexion. Note how much force being exerted to supinate to take picture.
After 15 Minutes of NMES to Biceps

Decreased hamstring length in right hemiplegia (left tight also):

Length increases following FES to hamstrings while walking on treadmill. Note braces.

Child with right hemiplegia attempting a handstand…trying his best to stay up.

NMES to the right biceps for 10 minutes, tries again, and success!
Child with left hemiplegia putting on FES for first time to biceps, brachioradialis, hand intrinsics for 15 minutes:

BEFORE

AFTER

Use it in function:

Following the short treatment, he begins to use his hand in play with a much improved wrist position.

6 weeks later, and had not had FES in 2 days:

Since the 1990’s, the focus in physical therapy has been on increasing strength in children with CP

• Numerous studies have focused lack of strength as the important aspect to “treat spasticity,” yet the solutions often weakened the muscles further (surgery-especially DSR’s and BTX dominated treatment)

• This focus was intensified when we discovered that “spastic” muscles were very weak.

"Despite challenges measuring muscle strength in CP, the lower limb muscle strength cannot be considered an explanatory factor for variations in standing in this group of children with bilateral CP. The findings rather strengthen our hypothesis that deficits in the sensory systems could be as determinant for standing as muscle weakness in children with bilateral spastic CP".

Despite asymmetric WB during standing, both limbs were equally strong in the two groups. No differences in strength were measured between the two seated conditions.

Cortical Synaptogenesis and Motor Map Reorganization Occur during Late, But Not Early, Phase of Motor Skill Learning
Jeffrey A. Kleim, Theresa M. Hagg, Penny M. VandenBerg, Natalie R. Cooper, Rochelle Bruneau, and Michael Remple, 2004

• Synapse formation and cortical map reorganization occur in the late phase of skill training
• Synaptogenesis precedes motor map reorganization, and is consolidated in the late phases of motor map reorganization

Motor training induces experience-specific patterns of plasticity across motor cortex and spinal cord
DeAnna L. Adkins,1,2 Jeffery Boychuk,1,2 Michael S. Remple,3,4 and Jeffrey A. Kleim 1,2,2006

Motor cortex and spinal cord alter circuitry in response to different motor training:
A. Skill training induces synaptogenesis, synaptic potentiation, and reorganization of movement representations within the motor cortex.
B. Endurance training induces angiogenesis in the motor cortex, but does not alter motor map organization or synapse number.
C. Strength training alters spinal motoneuron excitability and induces synaptogenesis in the spinal cord, but does not alter motor map organization

3 Training Experiences Induce Changes in the Spinal Reflexes That Are Dependent on the Specific Behavioral Demands of the Task

1. Training on a novel skill produces alteration in the spinal circuitry in the motor cortex that are specific to the muscle groups necessary for execution of the trained task and do not occur following simple repetitive use of those same muscle groups.
2. Strength vs. skill training influences the motor cortex.
3. Unlike skill training, strength training does not appear to induce reorganization of movement representations in the cortex!

Endurance training the primary effect of endurance training is on cerebro-vascular supporting change

The Unrelenting Misperceptions of Spasticity and Hypertonicity: Beth Fisher, PhD, PT, FAAPTA, Ryan Frendewey, PT, DPT, NCS, and Joseph Robinson, PT, DPT, NCS. CSM 2016

When in physical therapy history did tone or reflexive state of a muscle become connected to movement? Historically, there was “the perception that spasticity was the cause of movement dysfunction in patients with neurological dysfunction such as stroke and cerebral palsy. That perception led to a focus on interventions aimed at reducing spasticity. In particular, the assumption that spasticity was a direct cause of disordered movement came to dictate clinical practice.”

“Excess muscle activity during voluntary movement is too often mislabeled hypertonia when it truly represents compensatory behaviors.”

“Can chronic inactivation of a muscle lead to contracture?”

Charles Giuliani, 2002:
“If therapists can identify motor dysfunction using concepts of motor control and direct their intervention to the problems of control, the will be using a scientific approach to practice.”
Let’s talk about motor neurons...


• Expanding beyond the synapse as the focus of neuroplasticity.

• Multiple studies show that conduction velocity of the neurons could be modified through changes in the myelin to optimize timing through neural circuits—brain imaging reveals significant increases in white matter influenced by action potential firing in axons.

• Myelin is formed by oligodendrocytes (multipolar glial cells), which changes the way action potentials are propagated.

Electrical Stimulation

New evidence using IMRI shows brain changes over time when using NMES to augment active attempts at movement.

Voluntary effort in CP may not be the optimal training stimulus needed to recruit desired muscles for an activity.

--- Decreased motor unit recruitment
--- Decreased motor unit discharge rates

Electrical stimulation speaks the language of the nervous system by exciting the CNS.

Changes can occur in spastic muscles EVEN IF STIM IS ONLY GIVEN AT A SENSORY LEVEL OVER TIME.

After stimulation the excitability of the motor unit lasts for a time after treatment.

It is known that it electrical stimulation can increase gains.
Exercise vs Exercise with FES

Regeneration

Activity

Exercise with FES

Evidence for Selective Dorsal Rhizotomy

Most of the studies outcome measures are spasticity measurements.

Changes in synergistic movement patterns after selective dorsal rhizotomy (Oire, 2000).

Quantitatively compared movement patterns of 7 children without CP, with 27 children with a diagnosis of CP-spastic diplegia before and after SDR.

Results: Eight months after SDR, synergistic patterns did not significantly change from the preoperative results. "We conclude that it may not be possible to significantly alter synergistic patterns after SDR."

EB Literature SDR:

Dorsal Rhizotomy for Children with Cerebral Palsy: Support for Concepts of Motor Control. (Giuliani, 1991)

This article reviews the literature related to movement dysfunction, the effects of selective dorsal rhizotomy, and the evidence for disordered motor control in children with spastic cerebral palsy. Selective dorsal rhizotomy appears to reduce spasticity and increase joint range of motion. Abnormal movement patterns, however, persist after the spasticity is reduced. Well coordinated movement patterns are acquired slowly and appear to be related to an intense period of physical therapy. I argue that these results provide evidence that the presence of spasticity alone is an insufficient explanation for abnormal movement patterns. I propose that physical therapists redirect their efforts from developing methods for reducing spasticity to developing adequate assessment, treatment, and measurement techniques for assessing motor control in children with cerebral palsy.

An effective treatment for children with CP, SDR offers gains in strength, gait speed and overall gross motor function. (Engsberg, 2006)

The relatively high incidence of spinal deformity in children who have undergone SDR via multilevel lumbosacral laminoplasties should raise some concern. (Steinbok, 2005)

"SDR is a safe and effective method for reducing spasticity permanently without major negative side effects. In combination with physiotherapy, in a group of carefully selected and systematically followed young children with spastic diplegia, it provides lasting functional benefits over a period of at least five years postoperatively. (Nordmark, 2008)

But then....


The authors stated that, “a range of new interventions have become available mainly aimed at reducing muscle hypertonus and spasticity, such as selective dorsal rhizotomy, intrathecal baclofen, and intramuscular injections with botulinum toxin. However, the effects of the various treatments have been less than anticipated, particularly at the activity level...."

Literature SDR, 10 year follow-up:

"The spasticity-reducing effect of SDR, although pronounced, did not seem to improve long-term functioning or prevent contractures. This suggests that contracture development in CP is not mediated by spasticity alone." (Tedroff, 2011)

COORDINATION PATTERNS MAY BE AS DELETERIOUS TO MOTOR BEHAVIOUR AS SPASTICITY!

Objective: To conduct a systematic review and meta-analysis using the International Classification of Functioning to determine the summary effect of electrical stimulation on impairment and activity limitations relevant to gait problems of children with cerebral palsy.

Conclusions: “...determined medium effect sizes for electrical stimulation on walking impairment and activity limitations of children with cerebral palsy.


Five randomized trials were included. Three trials reported statistically significant between-group differences in favor of FES compared with no FES. Two trials reported no statistically significant between-group differences of FES compared with activity training alone.

Conclusion: The available evidence suggests that FES is more effective than no FES but that it has a similar effect as activity training alone in cerebral palsy.

Electrode placement on adductors, hamstrings during swing, and quadriceps during stance.

What does this do for the child?

So what if......we are not treating long enough to effect change?

- Long-term changes may take more than or 180 minutes (3 hours of treatment) over to 2880 minutes (48 hours, or 14 weeks of 2xwk treatment – longest study) during the intervention

- Although this is the current research, it may NOT be enough for motor learning to occur (2 studies lasted 1 week for 15 minutes duration, others lasted 2, 4, 6, 8 weeks). Parameter setting were all different, and all above 20 Hz

Hour numbers from Effect of Functional Electrical Stimulation on Activity in Children With Cerebral Palsy: A Systematic Review, Chiu (2014)
**Take Away from the Section on Pediatrics FES Course on the Evidence-Based Research, 2013: Gad Alon**

- “Most studies only last 4-12 weeks and then are terminated, regardless.”
- “Most patients do not meet inclusion criteria.”
- “Controversies regarding critical outcome measures (particularly critical to the patient).”
- “Transforming FES from clinical trials to daily practice will likely require a new practice model...it is so important to initiate training early and continue for many months, or even years.”

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**How Do You Learn To Walk? Thousands of Steps and Dozens of Falls Per Day (Adolf, 2012)**

- Typically developing 12-19 month olds averaged 2368 steps, travel 701 m-the length of 7.7 American football fields- and fell 17 times per hour!!!!!!
- Immense amounts of time distributed, variable practice constitute the natural practice regimen for learning to walk.
- Walking was distributed over time in primarily short bursts of activity.

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**Whole Body Vibration**

- Made in Germany by Novotec Medical GmbH.
- Galileo FDA approved 2002 and medical device Europe 2004
- StimDesigns LLC is the exclusive US Distributor
- It consists of a vibration platform that vibrates sinusoidal, side alternating like a see-saw.
- It oscillates with amplitude of up to 6 mm, equivalent to a peak to peak distance of 12mm.
- Frequency range of 5 Hz to 36 Hz.

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**Galileo Side Alternating Vibration System**

- Side alternating motion mimics human weight-shift during gait.
- The side alternating motion causes the hip to tilt, which activates the contra lateral muscles of the back.
- Compared to vertically vibrating devices the side alternating motion results in very low acceleration acting on the center of gravity of the upper body and the head.
Smaller version of the adult Galileo

Training Parameters
- Frequency - Number of repetitions per second
- Amplitude - Affected by distance between feet on the platform
- Body Position - dictates what muscles are activated by the vibration
- External Resistance - weights or manual resistance.

First time using WBV

Vibration Therapy

- In a small pilot trial in children, noted improvements in standing function, lumbar spine bone mineral density, tibial bone mass, and calf muscle cross-sectional area.

Vibration treatment in cerebral palsy: A randomized controlled pilot study.
Ruck 2010

- Experimental group received 9 minutes of side-alternating whole-body vibration (WBV; Vibraflex Home Edition II, Orthometrix Inc) per school day in addition to their school physiotherapy program.
- Patients who had received vibration therapy increased the average walking speed in the 10 m walk test by a median of 0.18 m/s (1) (from a baseline of 0.47 m/s (1)), whereas there was no change in the control group (P=0.03)

The effect of vibration therapy on spasticity and motor function in children with cerebral palsy: A randomized controlled trial, Katusic (2013)

- Vibration therapy may decrease spasticity and improve motor performance in children with CP. The results of the
- The results of this 3 month trial of 89 children serve as valuable input for evidence-based treatments in pediatric neurorehabilitation.
Effect of Whole Body Vibration Training on Mobility in Children with Cerebral Palsy: A Randomized Controlled Experimenter-Blinded Study, Lee and Chon (2013)

- Whole body vibration training leads to an improvement in gait function as measured by speed.
- Whole body vibration training appears to lead to increased strength in muscle, which may underlie the change in gait speed.
- Three-dimensional gait analysis and ultrasound imaging help elucidate the underlying effects of treatment.

Effect of a trunk-targeted intervention using vibration on posture and gait in children with spastic type cerebral palsy: a randomized control trial, Unger (2013)

- 27 children (6–13 years) participated in a single-blinded pre-post crossover experimental trial. 1-Minute Walk Test, 2D-posturography, ultrasound imaging and sit-ups in one minute were used to assess effect on gait, posture, resting abdominal muscle thickness and functional strength.
- Conclusion: A trunk-targeted intervention using vibration can improve posture and gait in children with STCP without any known side effects. It is recommended that vibration and specific trunk strengthening is included in training or rehabilitation programs. Effects of vibration on force generation and spasticity need further investigation.

Early vibration assisted physiotherapy in toddlers with cerebral palsy: a randomized trial, Stark (2016)

- 14 weeks sWBV with ten 9-minute sessions weekly (non-individualized). Group A started with sWBV, followed by 14 weeks without; in group B this order was reversed. Feasibility (≥70% adherence) and adverse events were recorded. Efficacy evaluated with the Gross Motor Function Measure (GMFM- 66), Pediatric Evaluation of Disability Inventory (PEDI), at baseline (T0), 14 (T1) and 28 weeks (T2).
- Conclusion: A 14-week home-based sWBV intervention was feasible and safe in toddlers with CP, but was not associated with improvement in gross motor function.

Alleviation of Motor Impairments in Patients with Cerebral Palsy: Acute Effects of Whole-body Vibration on Stretch Reflex Response, Voluntary Muscle Activation and Mobility, Krause (2017)

- After WBV, (1) SOL SRs were decreased \( p < 0.01 \) while (2) maximal voluntary activation \( p < 0.05 \) and (3) angular excursion in the knee joint \( p < 0.01 \) were significantly increased. No changes could be observed for GM SR amplitudes or ankle joint excursion. Neuromuscular coordination expressed by greater agonist–antagonist ratios during aROM was significantly enhanced \( p < 0.05 \).
Child Discusses Whole Body Vibration

Take home message:

- Biomechanical alignment is key for muscles to contract appropriately.
- Plasticity is driven by activity and experience—should be exciting to the child.
- Plasticity is driven by intensity, problem-solving, and repetition.
- A little electrical stimulation (even just cycling on and off) is better than no stimulation. Same with WBV.
- Start early and as often as possible. Get a home unit for the parent to use in a daily home program. Get insurance to cover WBV therapy for children with CP.
- We owe it to the kids and their families to fight for them to get the services they need—they are counting on us.