Integration of FSM into Pediatric Physical Therapy Treatment

Hilary B Coughlin, PT
Keith Filip, PT
Ben Katholi, MD
Regina Thompson, PT

Disclosures

- I have no financial disclosures
Objectives

- Define microcurrent therapy and frequency specific microcurrent therapy (FSM)
- Provide education on how treatment is defined and administered
- Provide case examples to demonstrate potential utilization in the rehabilitation setting
- Describe the clinical reasoning behind the use of FSM during physical therapy.
- Understand the importance that FSM is used in conjunction with traditional physical therapy interventions and is not a stand alone treatment.

Microcurrent therapy

- Traditionally known as M.E.N.S therapy, introduced in 1979
- Use of extremely small (less than 1 microampere) electrical currents using electrodes placed on the skin.
- Focused on pain and/or speeding healing and recovery
- Low versus high-frequency effects
Non-frequency specific microcurrent uses

- Acupuncture point stimulation
- Pain control
- Improved wound healing
- Sports injuries (tendon and ligamentous injury)
- Studied for age-related macular degeneration
- Plantar fasciitis
- This is fun, why stop here?

Frequency-specific microcurrent (FSM)

- Low intensity electrical stimulation initially developed in early 1900s
- Rediscovered and further studied at multiple centers
- Now in use across the US and internationally
- FSM utilizes defined frequency combinations to allow tissue specificity
  (MENS uses single frequency at a time)
How is it administered?

Two separate channels
One channel focused on the “condition”
Second channel focused on the affected tissue
Can be either alternating or polarized ramped square wave
Utilizes interferential effect (the intersection of the two frequencies)

Equipment needed

- 2 independent channels
- 3 digit specificity (1hz or 396 hz)
- Interferential pattern (4 leads)
- Pulse alternating or pulsed positive polarizable DC current
- Ramped square wave
- Constant current generator
FSM

- Effects include:
  - Boost ATP production up to 500%
  - Increased protein synthesis by 70%
  - Increased amino acid transport by 40%
  - Activates signal tranduction
  - Increased cAMP in human lymphocytes (in vivo)

- Seegers, JC, 2001; Activation of signal transduction mechanisms may underlie the Therapeutic effects of an applied electric field. Med Hypothesis; 57 (2), 224-230
- Seegers JC, 2002, A pulsed DC electric field affects P2-purinergic receptor functions by altering the ATP levels in in vitro and in vivo systems. Medical Hypothesis, 58 (2) 171-176

FSM

- How does it work?
  - Each tissue has specific frequency at which is resonates
  - Effects not fully understood
  - Operates on the fact that the body is electromagnetic semiconductor
  - The body is able to transmit current and charge (ie nerve depolarization)
Noted effects during treatment

- Tissue softening
- Sensation of warmth
- The effects stop when change is complete
- Lasting effects

Resonance

- A tendency of the system to oscillate at large amplitudes in response to specific frequencies
- Small forces can produce large amplitude vibrations
- Every bond in the body has a resonant frequency
- Resonance likely affects cell-cell signaling (cytokine reductions)
FSM vs TENS

- FSM utilizes millionths of an amp and is subsensory. Does not stimulate sensory or motor nerves, and can stimulate ATP production.
- TENS is not subsensory, and stimulates sensory and motor nerves. Can potentially reduce ATP production.

FSM vs Alpha Stim

- Alpha Stim is a microcurrent therapy but utilizes a patented variable frequency waveform at 0.5 hz
- Primary indications for Anxiety, Depression, Insomnia, Chronic pain
- No ability for tissue specificity
Important qualifiers

- FSM works only with appropriate diagnosis (ie, there is little to no notable effect with inappropriate tissue focus)
- Hydration important
- Condition of the patient affects success of the treatment
- Cannot replace non-existent tissue

Commonly treated conditions thus far

- Acute/chronic musculoskeletal injuries
- Acute/chronic neuropathic pain
- Chronic fracture and bone pain
- Arthritis
- Torticollis
- Discogenic and facet based pain
- Viscerally referred pain
- Concussions
- Fibromyalgia
- Headaches (multiple subtypes)
- Tendon injuries/Tendonopathy
- Wounds
- Burns
- Spasticity and Dystonia
- Ehlers-Danlos syndrome
- ADHD ***
- Feeding disorders ***
Typical treatment

- Patient seen, history reviewed, and examined thoroughly
- Important focuses of exam should include dermatomal examination, reflexes, functional examination including gait, localization of symptoms
- Exclude potential factors which could effect success of treatment such as existing infection, deficiency, etc.

Potential contraindications

- Pacemakers, implanted pumps (cannot treat directly over)
- Seizures (no scalp based treatments)
- Certain frequencies contraindicated for acute infection, new scar tissue (within 6 weeks), fracture (healing vs new)
- Pregnancy (cytokine-dependent fetal development)
Evidence thus far

- Multiple case studies presented yearly
- Studies include NIH, Burn center, Adhesion trial, DOMS, Aphasia, PTSD, LFTs, Cytokines, Inflammatory responses, neuropathic pain, fibromyalgia
- Research is planned at our center on multiple topics (IRB in process)

Why use it?

- Enhance recovery in chronic conditions
- Reduce symptomatology of acute injuries
- Enhance rehab therapies and outcomes
Basic Strategy

- What is causing the symptoms?
- What is wrong with the system that is causing the symptoms?
- Treat through the basic pain strategy
  - Remove any pathologies from tissues
  - Support the system

Basic Pain Strategy

- Treat the NERVE
  - Nervous system: brain, spinal cord, nerve
- Treat the MUSCLE
- Treat the JOINT
- SUPPORT the tissues
Case Study #1 (11 year old male)

- History: B. is an 11 y/o boy who suffered an anoxic brain injury in December 2014 secondary to cardiorespiratory arrest.
- Secondary impairments: gross motor, fine motor, and speech along with post-hypoxic tremors and spasticity.
- Current Status: He demonstrates ataxic gait, dysmetric movements, decreased motor processing time and continued impairments in memory, cognition and management of thin liquids.
- There has been minimal response to medication treatment for tremors.
- His cardiac arrest was result of an asthma attack set off by his allergies to cats, he was exposed to cats at the time of the incident.
- Family/Patient Chief Complaint: tremors, ataxia

Anoxic Brain Injury

- Cerebellum
  - Responsible for fine tuning and coordination of movement
  - Responsible for motor memory, storing learned sequences of movement
  - Responsible for balance, equilibrium and muscle tone
  - Play a role in motor learning and modifying motor commands from the descending pathways and helps to initiate and coordinate the activation of muscles in the right sequence.
  - The cerebellum modifies motor commands from descending pathways to make movements more adaptive and accurate to the task.
- Basal Ganglia
  - Cluster of nerve cells that receive information from the cerebral cortex than return it to the motor cortex via the thalamus.
  - Basal ganglia then facilitate movement by channeling information
  - They also may act as a filter, blocking movement that is not suitable to the situation.
  - The basal ganglia circuits are also involved in memory, cognition and emotional processing.
- Sensory Cortex (within parietal lobe)
  - Sensory integration, processing, spatial orientation, pain sensation, visual perception, touch sensation, hot/cold sensation, complex language processing
Clinical Thinking

- Anoxic Brain Injury
  - Generalized damage to the brain
- Promote Healing
- Promote Function
- Allergy
- Tissue Degeneration
- Emotional Response

Treatment

- FSM was provided during treatment sessions while engaged in therapeutic tasks
  - Hand writing
  - Ambulation
  - Standing
Progress

- Tall kneeling
  - Prior to FSM treatment patient could only maintain static tall kneeling for 7 seconds
  - Following FSM treatment patient could:
    - Maintain for 1 minute
    - Tall kneel walking forward 6 feet
    - Engage in a catch/throw activity in tall kneeling

- Ambulation
  - Ataxic gait, narrow BOS, in toeing bilaterally, excessive trunk movements
  - Equipment: solid AFO’s, rolling walker at home (not recommended by PT)
  - Walking short distances in therapy sessions with UE support anterior from therapist and consistent scissoring pattern with left LE crossing midline.
  - During FSM treatment patient was able to ambulate using less UE support and maintain consistent left LE position in line with hip and no scissoring pattern.

Progress (cont.)

- Handwriting
  - June 2015, unable to stabilize the pencil on paper without moderate assistance. Unable to write initials on 8x11 sheet of paper secondary to ataxia. No ability to stabilize his shoulder, forearm or wrist for purposeful movements
    - Interventions attempted with minimal success: wrist weights, pencil weights
  - January 2016, able to write his initials on a half quarter sheet of paper
  - February 2016 - initiate FSM treatment, immediate changes within session for handwriting
  - 6-8 weeks of continued FSM treatments and practice, he’s able to maintain the quality and currently writing his initials in a 2 inch box
Progress (cont.)

Working on maze drawing which therapist would never have had him attempt secondary to level of difficulty, however he is able to complete.

Case Study #2 (10 year old female)

- History: R is a 10 year old girl with a history of mixed cerebral palsy with spasticity, spastic quadriplegia, dystonia, choreoathetosis.
  - S/p posterior spinal fusion with instrumentation on 3/2/2015
    - 8 weeks s/p spinal fusion at time of evaluation
  - Intra-thecal baclofen pump - 1000 mg per day
  - Other difficulties include constipation, feeding difficulties, scoliosis, reflux
  - Dependent for all transfers and self care
- Chief Complaint: experiencing increased pain and tightness on her right side since surgery (specifically right neck, right leg and right knee). Family having increased difficulty with performing dressing, diapering and positioning in wheelchair.
**Functional Impact**

School uses eye gaze system

- Constant right head turn impacting her ability to communicate/engage
- Trial with right arm switch

Treatment prior to FSM with focus on soft tissue mobilization of cervical musculature

- Responded well with minimal carry over from session to session
- Used positioning of wheelchair to encourage looking to midline and left

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**Clinical Thinking**

- Initially to treat the affected structures:
  - muscle, fascia, and tendon
- Source of spasticity is a central - cortical problem
  - Need to treat motor and sensory areas
- Many of treatment interventions for spasticity are local to affect the CNS
  - Stretching, casting, botox, bracing
- Most effective and long lasting is treat source
  - CNS
Results

- Effects of FSM have lasted for 4 weeks
- Total body relaxation
  - Bilateral UEs into extension at her sides (getting through doorways)
  - Able to actively turn head to left
  - Right hand opened up for better attempts at switch activation
- Family questioning need for further botox injections
- Change in position for feeding with head in midline
- Significantly decreased complaints of pain
- Much improved tolerance of positioning in power wheelchair
- Improved ease ability to complete dressing and toileting

During Treatment
Case Study #3 (3 year old male)

- **History:** C is a 3 y/p boy with a history of spastic quadriplegia, femoral torsion and sensory aversion. He underwent a selective dorsal rhizotomy in December 2015 and admitted to intensive therapy outpatient program.
- **Chief Complaint:** aversion to weight bearing, inability to calm self and poor tolerance to therapy with crying throughout any treatment sessions.
- **20 days of traditional sensory regulatory techniques where performed during his 3 hours of therapy with minimal to no change in his tolerance to activities**
  - Brushing, joint compression, swinging/vestibular input

The Brain as a Sensory Processor

- **80% of the nervous system is involved in processing or organizing sensory input**
- Sensory input is typically directed to the relevant primary and secondary specialized areas in the cerebral cortex
- Proper sensory integration is not isolated to a single cortical structures, but instead is inter-connected to many other areas of the nervous system
Sensory Integration and Learning

- With increased efficiency of integrating sensory information, a specific motor output becomes more refined
- Sensations can further be anticipated with mastery of a certain motor skill allowing for smooth and coordinated movements
- Sensorimotor development provides the foundation for later cognitive functions

Clinical Thinking

- Central Nervous System
  - Sensory processing
  - Anxiety
  - Pain
- Targeting areas of the brain that are not being regulated in a typical fashion and encourage increased participation/coordination of motor tasks
- Promote balance and relaxation
- Promote calming and self regulation
- Support the system
Treatment & Progress

- FSM initiated by medical staff and then patient seen in PT
- Following 1st treatment: patient ambulated 15 steps with moderate assist and no crying
  - Prior session previous day took 10 steps with maximal assist and crying
- FSM sessions were followed up during PT sessions. With each session, patient progressed with increased steps during ambulation and increased standing tolerance with decreased crying/screaming
- FSM used during therapy treatments, during standing and ambulation activities. OT noted carry over with improved tolerance to standing during their sessions

Section on Pediatrics: Torticollis defined

“Torticollis is a common pediatric musculoskeletal condition, described as a postural deformity of the neck evident at birth or shortly thereafter. It is characterized by a head tilt to one side with the neck rotated to the opposite side due to unilateral shortening of the sternocleidomastoid, and associated cervical muscles.” (Kaplan, et al)
Torticollis; Primary Impairments

- Shortened, contracted, *fibrotic* Sternocleidomastoid muscle (SCM) due to trauma, or repetitive microtrauma (persistent intrauterine positioning, compartment syndrome)
- With or without a palpable mass
- Limitations in passive and active range of motion
- Weakness

Torticollis; Secondary impairments

- Delay in antigravity head control
- Poor midline development
- Delayed hand-eye development
- Plagiocephaly and craniofacial asymmetry
- Visual disturbances
- Hip dysplasia
- Compensatory scoliosis
- Delayed integration of primitive reflexes
Literature - Muscle Pathology of Torticollis

- Injured or damaged muscle demonstrates increased Ca2+ concentration
- Sustained increases in Ca2+ may change activation level of Ca2+ sensitive substrates, which affect cell membrane permeability (Belcastro, Jackson, Armstrong)
- Increased Ca2+ concentration leads to fibrosis of muscle due to activation of Calpain (Belcastro, Lambert, Chen et al)
- Calpain and other proteins in muscle lead to muscle atrophy and proliferation of fibrous and adipose tissue in the SCM (Chen)

SCM Fibrosis

A-B Histological micrographs of a sample of a 12-month-old patient with CMT show (A) the atrophic muscle fibers (white arrow) surrounded by the proliferating fibroblasts (yellow arrow) (H&E staining, ×400 original magnification). In a sample of a 17-month-old CMT patient, longitudinal section shows (B) the adipocyte hyperplasia (yellow arrow) around atrophic muscle fibers (white arrow) (H&E staining, original magnification ×100).

Chen 2014
SCM Atrophy-calpain staining

The sections obtained from muscles of controls (13 months’ old) and 2-year-old patients with CMT. Immunostaining for (A) calpain-1, (C) cubiquitin, and (E) 20S proteasome were very weak in the muscle cytoplasm of the control. But, in the CMT specimen, atrophic muscle fibers showed moderate (yellow arrow) or strong (red arrow) immunoreactions for (B) calpain-1, (D) ubiquitin, and (F) 20S proteasome (×400 original magnification).

Chen 2014

APTA CPG Recommendation on Microcurrent

- First choice intervention - Action statement 12:
  - Stretching
  - Strengthening
  - Positioning
  - Home programming
- Second choice intervention - Action statement 13; use microcurrent if progress is slowed with conservative methods
- Decreased treatment duration reported - Kwon and Park, 2014
- Increased range of motion reported - Kim et al, 2009
Clinical Thinking

- Restore Ca²⁺ homeostasis
- Accelerate healing on the targeted structures known to contribute to postural deviations
  - Muscle
  - Tendon
  - Fascia
  - Connective tissue
- Neurological Structures- support for improved function
  - Medulla and spinal segments C1-5 for the spinal accessory nerve to the SCM and trapezius
  - Sensory motor cortex, cerebellum

Focus of Torticollis Treatment with FSM

- Facilitate homeostasis of muscle
- Increased passive and active range of motion achieved during session
- Postural Reeducation for motor skills
- Deeper stretch obtained with use of FSM
- Multiple structures can be treated
- Grouping of frequencies
  - Mild: 2 protocols targeting muscle and neurological structures.
  - Moderate: targets muscle structures, includes vertebrae
  - Severe: includes vestibular structures to address additional contributing factors
Case Study #4 (6 month old female)

- History: M was a 6 month old female referred for treatment for torticollis. Parent reported a precipitous birth, with a noticeable head tilt at birth. M was referred at 6 months of age and presented with Grade 3, early, severe torticollis. (Kaplan)

- Chief Complaint:
  - 30 degree left tilt in supine, greater in sitting. At evaluation, passive right lateral flexion 5 degrees, passive left rotation 50 degrees. Delayed motor skills.
  - Active neck extension in prone 45 degrees, head lag in pull to sit 20+ degrees. Poor hand eye coordination left. Poor midline development.

Treatment Strategies

- Stretching, strengthening, positioning, parent education of home programming
- Kinesiotaping, TOT collar, FSM, orthotic
- FSM observations
  - Observed to soften muscle
  - Enhance active range of motion by 10 or more degrees within a session
  - Treated with mild muscle, moderate and severe protocols
Nearing Discharge

- Full active and passive cervical rotation
- Full active and passive lateral cervical flexion
- Age appropriate motor skills
- Occasional left head tilt of 5 degrees, controlled with orthotic and targeted postural reeducation exercise

Bibliography

Bibliography

Cleveland Clinic

Every life deserves world class care.