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Novel Method for Measuring the Kinematic Effects of Neuromuscular Electrical Stimulation (NMES) in Swallowing Therapy

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Disclosure of Conflict of Interest

- **Rick McAdoo: Rick has intellectual property rights, holds a patent on Ampcare ESP Technology and receives compensation for its sale. He is employed by and has ownership interests in Ampcare, LLC, and receives a salary. Nonfinancial: He has no relevant nonfinancial relationships to disclose.**
- **Russ Campbell: Russ has intellectual property rights, holds a patent on Ampcare ESP Technology and receives compensation for its sale. He is employed by and has ownership interests in Ampcare, LLC, and receives a salary. Nonfinancial: He has no relevant nonfinancial relationships to disclose.**

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Objectives

- Discuss Electrotherapy Parameters
- Identify the Strength Duration Curve and describe the relationship between intensity and phase duration
- Understand the All-Or-None Law as it relates to a motor unit
- Demonstrate how the hyoid and laryngeal vestibule kinematics can be measured.
- Review recent research data using kinematic measures supporting diet outcomes (PAS)

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Electrotherapy Currents

	Alternating Current	Pulsed Current			Direct Current
	IFC Premod Russian	HVG	Neuromuscular Electrical Stimulation (NMES)	TENS	Ionto-phoresis
Indication	Pain Edema	Edema, Wound Care	**Prevent disuse atrophy, increase ROM muscle re-education**	Pain	Edema, Pain
Frequency	Carrier Freq 4000Hz, Modulated Freq 4001-4160Hz	1-120Hz adj	**1-160Hz adj**	1-120Hz adj	10Hz-50kHz
Phase Duration	125µs	100µs	**50-250µs**	50-450µs	Continuous or pulsed
Channels	2	1	**2 - 4**	2	1
Set-up	Bi or Quadripolar	Bipolar	**Bipolar or Quadripolar**	Bipolar or Quadripolar	Bipolar
Waveform	Symmetrical balanced sine wave	Mono-phasic Dual Spiked Wave	**Asymmetrical or Symmetrical Biphasic Square Wave**	Modified Asymmetrical Biphasic Square Wave	Mono- or biphasic, or quadratic
Output	1-60mA into 500Ω	1-300V	**1-100mA into 500Ω**	1mA-70mA into 500Ω	1-4mA

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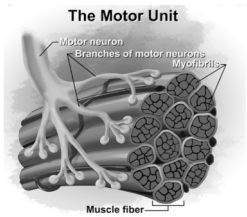
The Role of Motor Units

- Motor Nerve
- Neuromuscular junction
- Muscle fiber
- Myofibril with myofilaments inside



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NMES Parameters

- **Intensity** is the current generated by the stimulation device.
  - Speed of current flow:
    Weak current = (low intensity or lazy river)
    vs.
    Strong current = (high intensity or raging river)
- Current is delivered is milliamps (mA).
- High intensities will penetrate deeper stimulating more motor units.

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Rules to Electrotherapy

All-or-None Law

- When a nerve receives a stimulus of sufficient intensity, the nerve and muscle fiber will give a maximal response; otherwise, there is no response.
- So electrical current is either sensory (submaximal) or sensorimotor (maximal).

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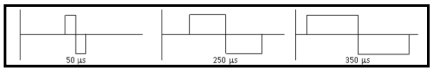
NMES Parameters

- **Phase Duration:** is the measurement of either the + or – phase of the pulse measured in microseconds (µsec).
  - Traditionally, higher phase durations yield deeper penetration, which can create a deep pain or discomfort that may counteract the benefit of the NMES.



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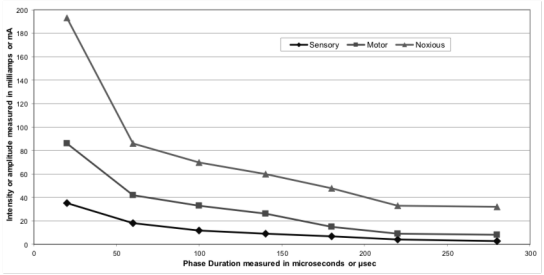
Strength Duration Curve



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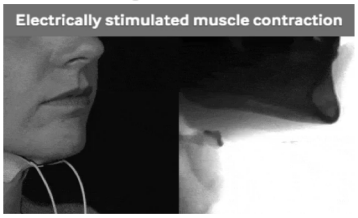
What is NMES?

- Electrically stimulating nerves causing **muscles** to **contract** recruiting more fibers than a patient can do on their own for therapeutic benefit



Baker et al., 1993

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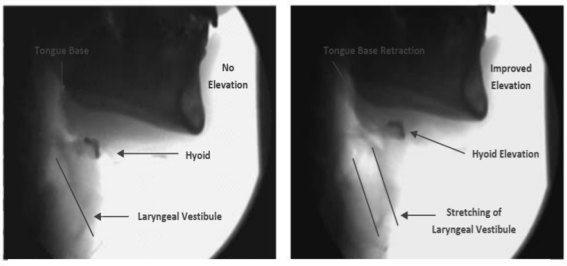
Ampcare's Effective Swallowing Protocol (ESP)



Patient at rest **Patient receiving Ampcare's ESP**

- The use of suprahyoid only placement → generating suprahyoid muscular contractions to facilitate laryngeal elevation.
- Appropriate NMES parameters in line with small muscle function → sufficient frequency (30 Hz) and low phase duration (50µs)(Baker et al., 1993).

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FEES Example

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NMES WRIST EXTENSION

Demonstration

Background

- Neuromuscular Electrical Stimulation (NMES) has been widely used across disciplines for decades (Lake, 1994; Ward and Shkuratova, 2002).
- Given the exposure Speech Pathologists/Therapists (SLP/SLT) have to NMES, and the populations they encounter, the potential to use this modality is accessible.
- However: many different available parameters and approaches used (Bath et al., 2016; Furuta et al., 2012; Mituuti et al., 2018) provide unclear evidence on how to appropriately implement NMES (Bath et al., 2018) to treat dysphagia.

Background

- Electrode placement of NMES delivered is another issue leading to mixed results.
- NMES is designed to: generate muscular contractions, facilitate movement, and to do them together (Doucet et al., 2012) to improve functioning progressively (Maffiuletti, 2010).
- In using NMES for dysphagia, it is paramount to implement treatment in a way that accomplishes those treatment principles.
- Based on the physiological function of the suprahyoids, (Shaw et al., 2017) suprahyoid placement & targeting of NMES is likely the most beneficial approach ➔ current evidence shows positive outcomes (Martindale et al., 2019; Sproson et al., 2018).

Background

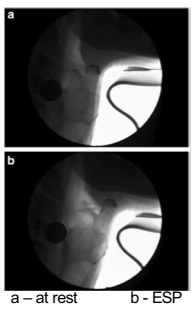
- Perturbation of the laryngeal vestibule is also a consideration of NMES.
- Studies with mixed parameters and placements have found no significant effects of NMES on laryngeal vestibule kinematic timing parameters previously (Arslan et al., 2018; Humbert et al., 2015).
- Others utilizing NMES on the suprahyoids have found improved laryngeal vestibule closure reaction timings in healthy adults (Watts and Dumican, 2018).

Methods

- VFSS were loaded into TIMS-DICOM software for review.
- All measurements (hyoid, laryngeal vestibule kinematics, PAS scores) were completed within TIMS-DICOM reviewer.
- For hyoid movements, a standardized calibration referent (a penny; 19.05 mm) was used. All hyoid movements were measured in absolute distance after calibrating to this referent.

TCU Research Utilizing ESP (2018)

- 9 Healthy Participants
- 3 Pre-stimulation swallows (no ESP applied)
- 10 Swallows while ESP was applied
- 3 Post-stimulation swallows (no ESP applied)
- **Mean of 39%** faster laryngeal vestibule closure reaction time



a – at rest b - ESP

Watts et al., 2018

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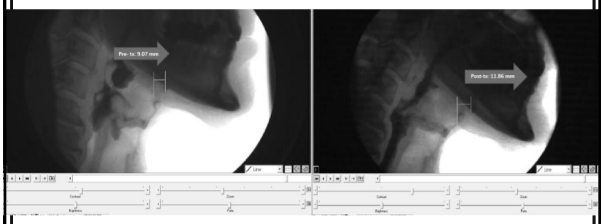
Pre-Post Treatment Measurement of Anterior Hyoid



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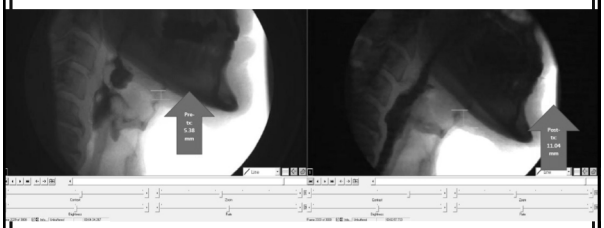
Pre-Post Treatment Measurement of Superior Hyoid



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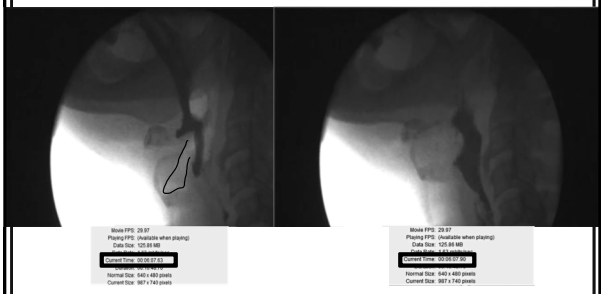
Pre-Treatment Measurement of LVCrt



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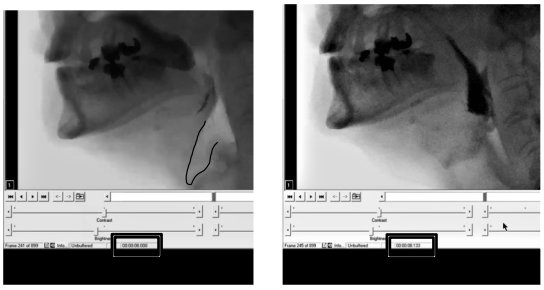
Post-Treatment Measurement of LVCrt



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Methods

- Primary analysis of retrospective swallow studies (VFSS).
- Small, clinical cohort (n=11) diagnosed with pharyngeal stage dysphagia post-stroke and undergoing primary treatment of dysphagia with NMES.
- All subjects completed at minimum 30 days of treatment and a minimum of 30 minutes per therapy session utilizing Ampcare's Effective Swallowing Protocol (ESP) device and parameters prior to follow up VFSS.
- Initial (pre-treatment) and most recent available VFSS of each patient were compared.
- Dumican, (Western Michigan) –World Dysphagia Summit - 2021

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Results

- Were there differences in pre- and post-treatment hyoid movement and kinematic timings for individuals?
- What are the biggest contributors to a patients swallowing function post-treatment?
- Did PAS scores improve?
- What is the likelihood of penetration or aspiration post-treatment?

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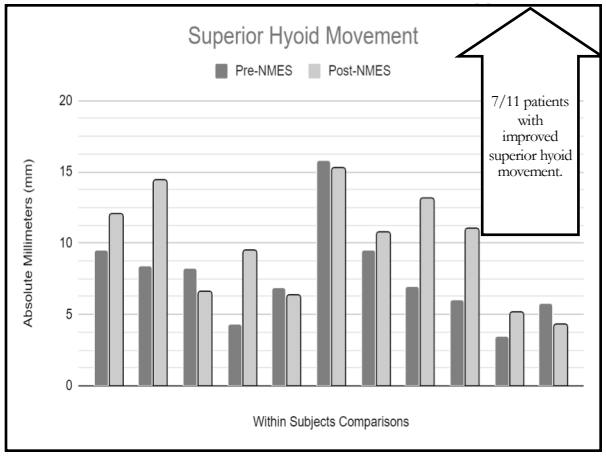
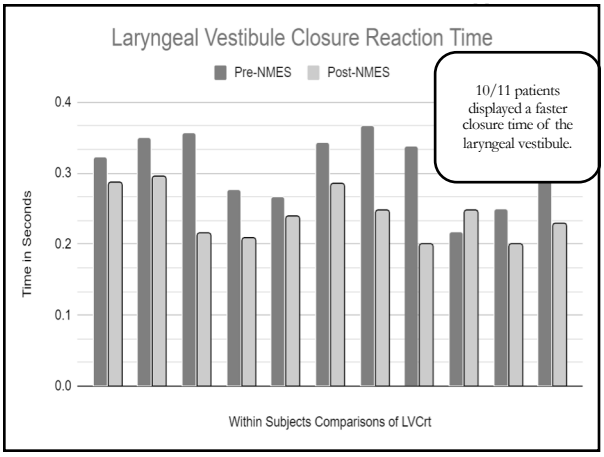
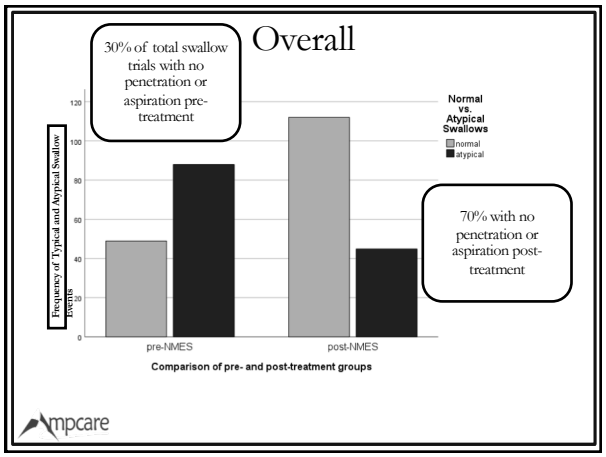
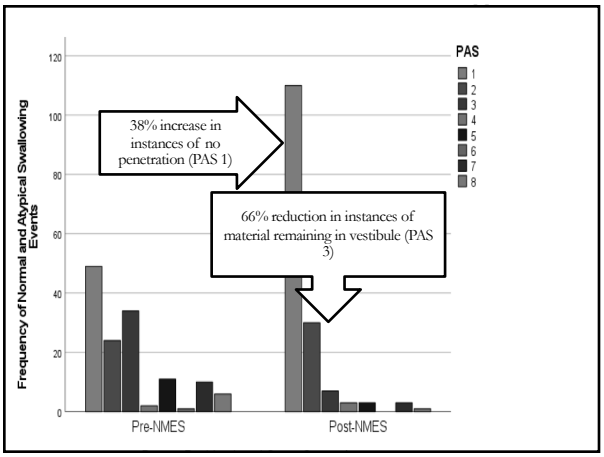
GSHA 2022







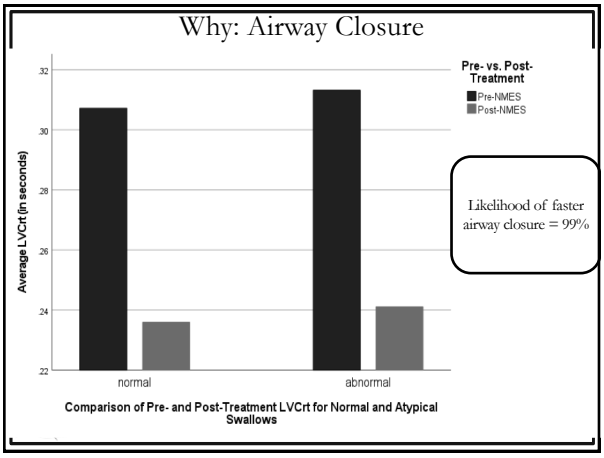


Post-Treatment Impact: PAS by Consistency and Volume

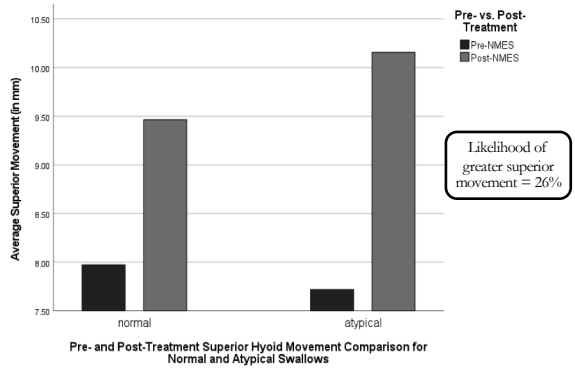
Subject	Worst PAS	Consistency	Worst PAS	Consistency
1	7	Tbsp Nectar	7	Thin by straw
2	4	Tbsp Nectar	2	Thin by straw
3	6	Tbsp Pudding	1	All consistencies
4	8	Tbsp Pudding	8	Thin by cup
5	8	Nectar by cup	4	Thin by cup
6	7	Thin by cup	5	Thin by straw
7	8	Thin by cup	3	Thin by cup
8	7	Thin by cup	3	Tbsp thin
9	7	Nectar by cup	4	Thin by cup
10	7	Tbsp Pudding	7	Thin by straw
11	7	Tbsp Pudding	7	thin by straw

7/11 patients improved their worst PAS score overall.

All patients displayed improved tolerance to bolus consistencies/volumes.



Why: Superior Movement



Likelihood of greater superior movement = 26%

Thank you!!!

Questions?

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