

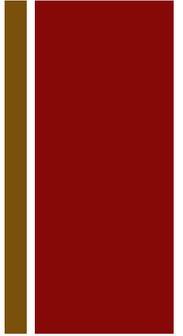


# **Functional electrical stimulation (FES) in horses for musculoskeletal rehabilitation**

Prof Sheila Schils, MS, PhD



# Purpose of this presentation



- Outline the specifics of the FES system use in equine rehabilitation
- Discuss case studies and evaluate protocols for using FES in horses



# EQUINE FES SYSTEM SPECS

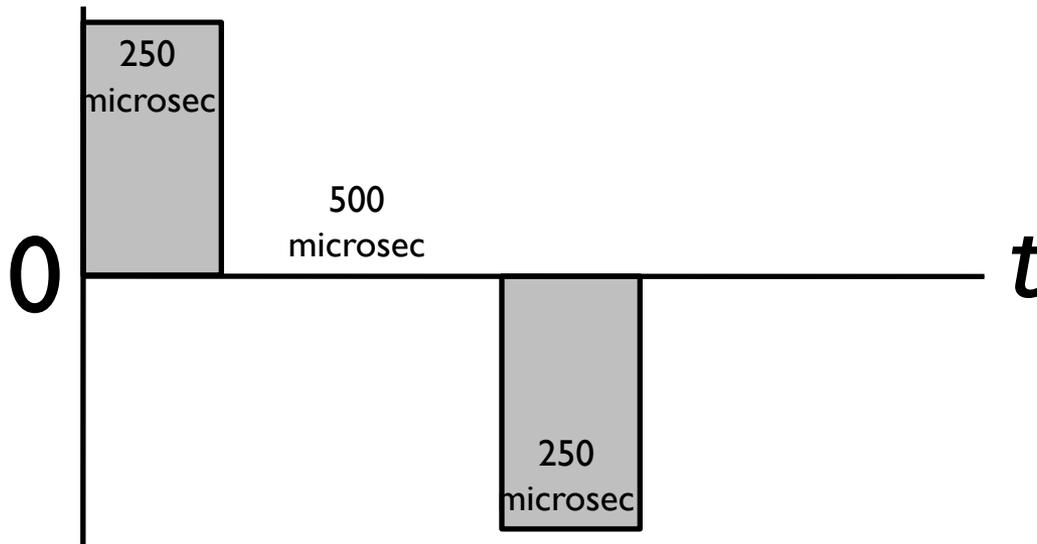
# FES310 Parameters

- Digital controller with 16-bit microcontroller
- Constant voltage
- Waveform
  - Rectangular, balanced, biphasic
- Stimulation frequency
  - 60 Hz
- Duty Rate
  - Approximately 2 seconds on/off



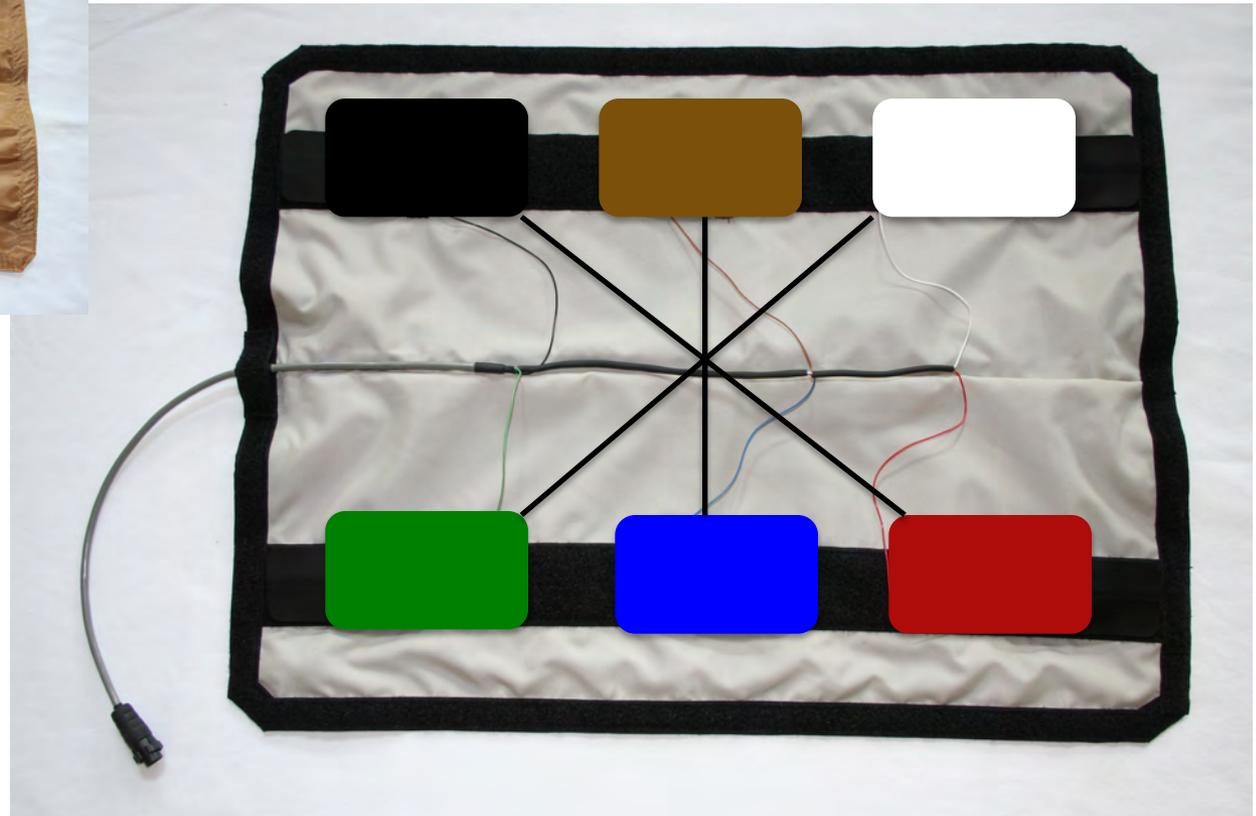
# Pulse Parameters

- Ramp up positive pulse
- Ramp down to baseline
- Ramp down negative pulse
- Ramp up to baseline

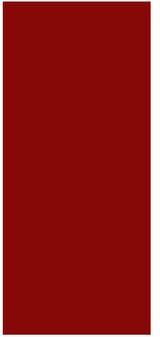


# Equipment

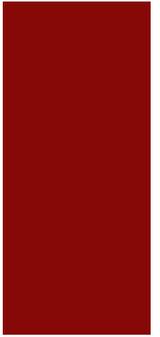
Surface electrodes in pad or self-stick  
6 electrodes in an “asterisk” pattern



# + Site preparation



# + Attaching FES system





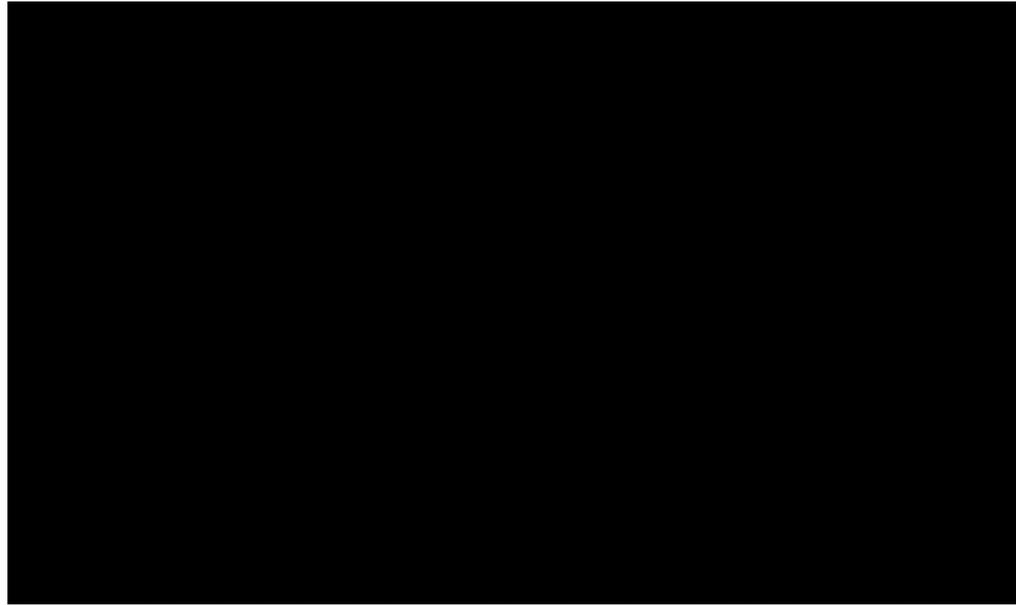
# Functional Electrical Stimulation Top Line



FES set up for SI treatment



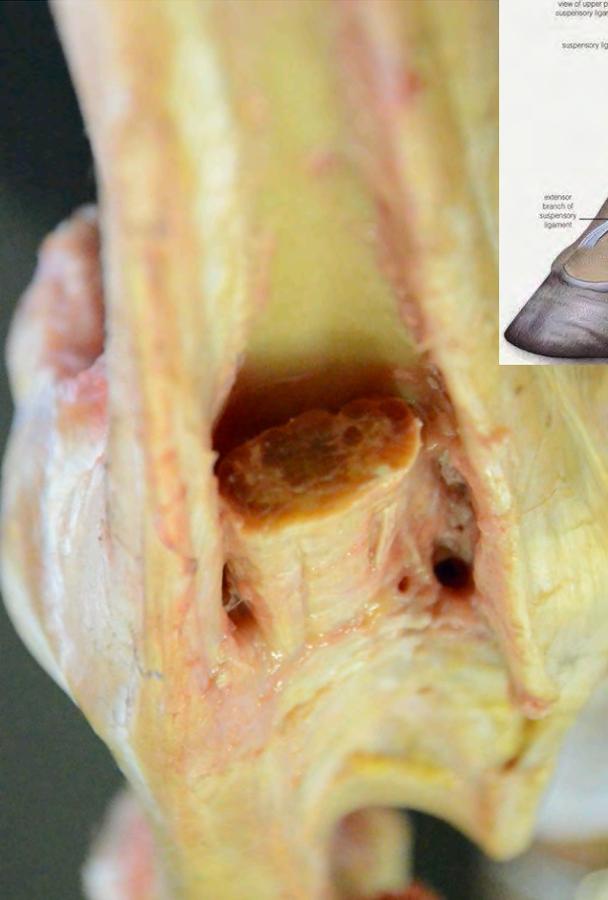
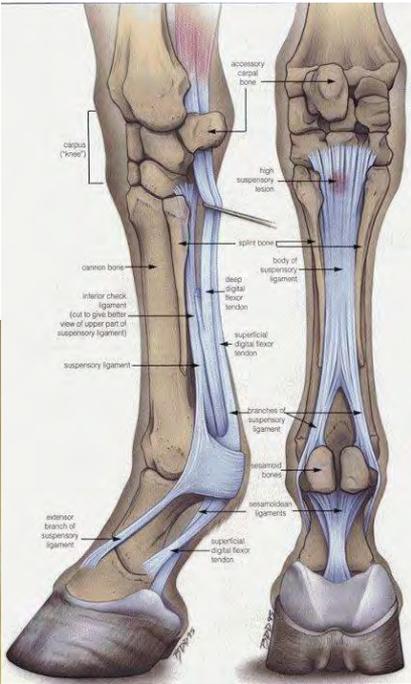
FES treatment



# FES thorax region



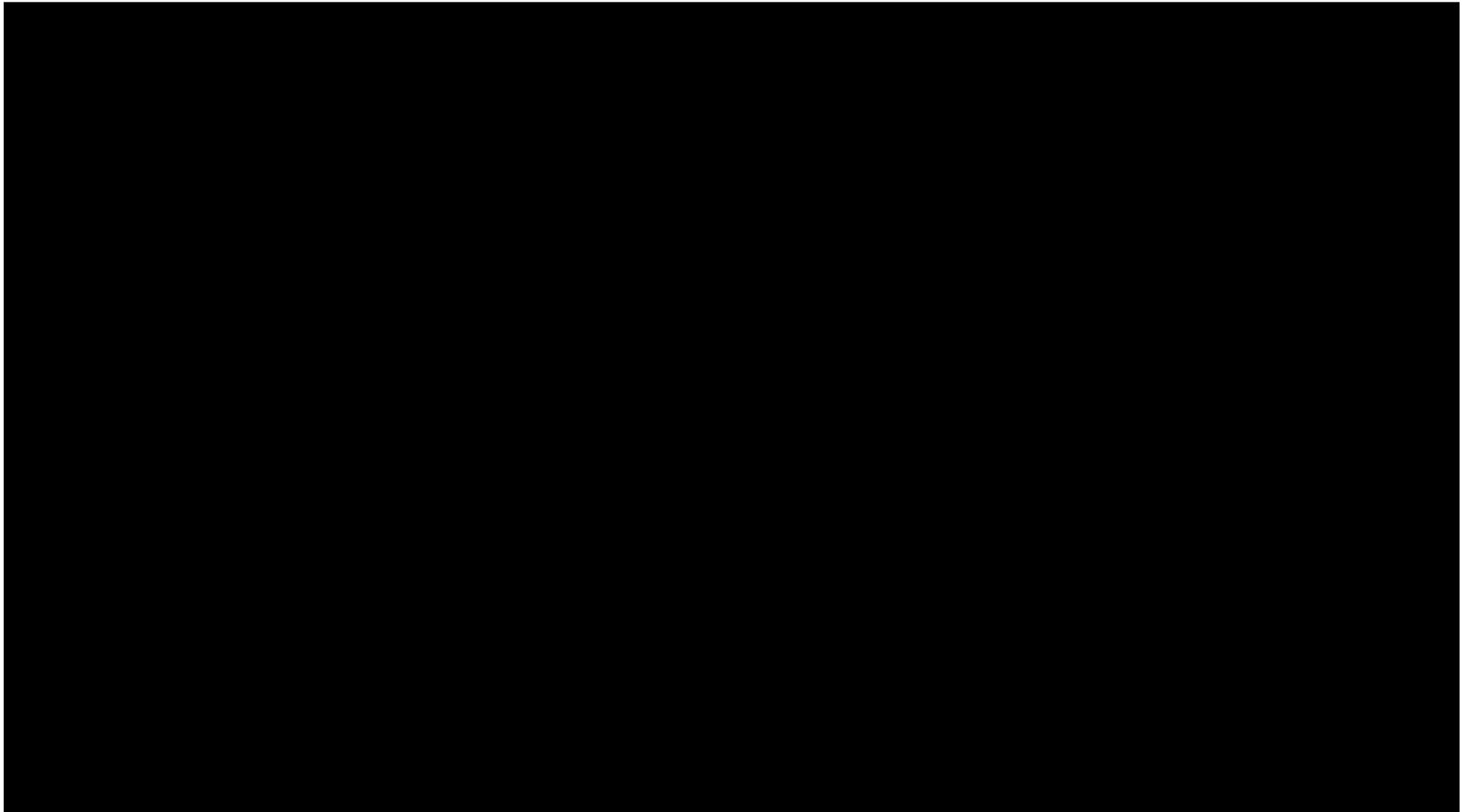
# +FES distal limb



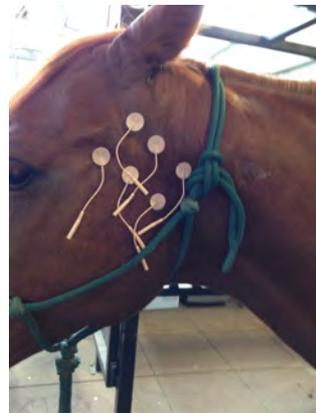
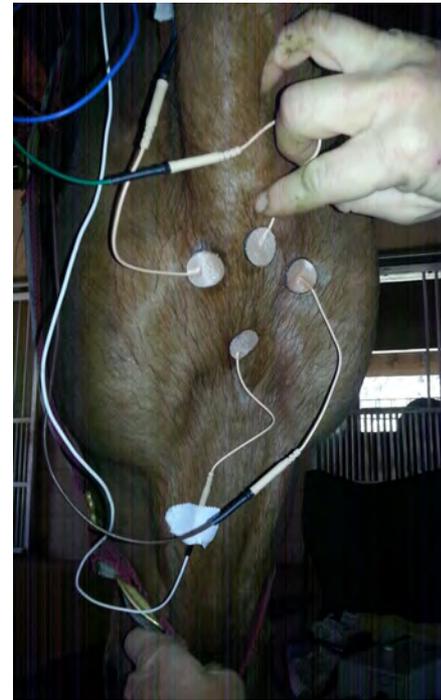
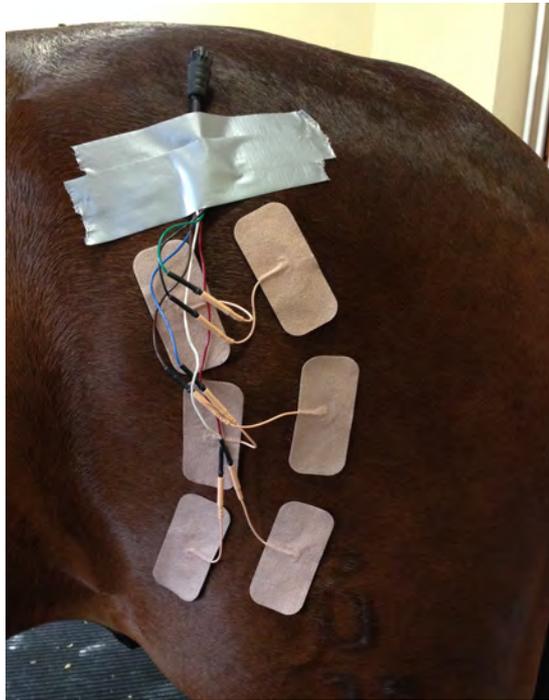
# Ultrasound taken during FES stimulation

## Activates muscles up to 15cm in depth

- Contractions in sequence with on/off pulse



# + Treatment Site Examples



# FES clinical treatment protocol

- 5-7 volts produces initial motor contractions
  - In humans 20-25 volts produces motor contractions
  - Thicker hair coat more voltage (about 3 volts)
- 7-10 volts produces functional movement
  - Articular or vertebral movement elicited
- 20-35-minute treatment
  - 525 cycles per treatment period
- Two successive treatments within 24 hours
- Excellent compliance
- Improvement can be observed quickly

# FES clinical treatment protocol

Situation	Category	Treatment
<b>Dorsal Thoracic Lumbar/Sacral Pain</b>	Acute	2 Rx within 12-48 hrs 3 Rx within 3 wks
<b>Dorsal Thoracic Lumbar/Sacral Pain</b>	Chronic	2 Rx within 12-48 hrs 3 Rx within 3 wks 6 Rx within 1 yr
<b>Kissing Spine</b>	Chronic	2 Rx within 12-48 hrs 3 Rx within 3 wks 12 Rx within 1 yr
<b>Decreased Performance</b>	Preventative	2 Rx within 12-48 hrs 2 Rx within 3 wks 4 Rx within 1 yr
<b>Muscle Atrophy</b>	Chronic	2 Rx within 12-48 hrs 3 Rx within 3 wks 6 Rx within 1 yr

# Pre: Lumbosacral and thoracic FES

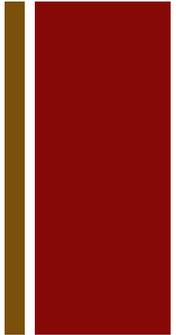
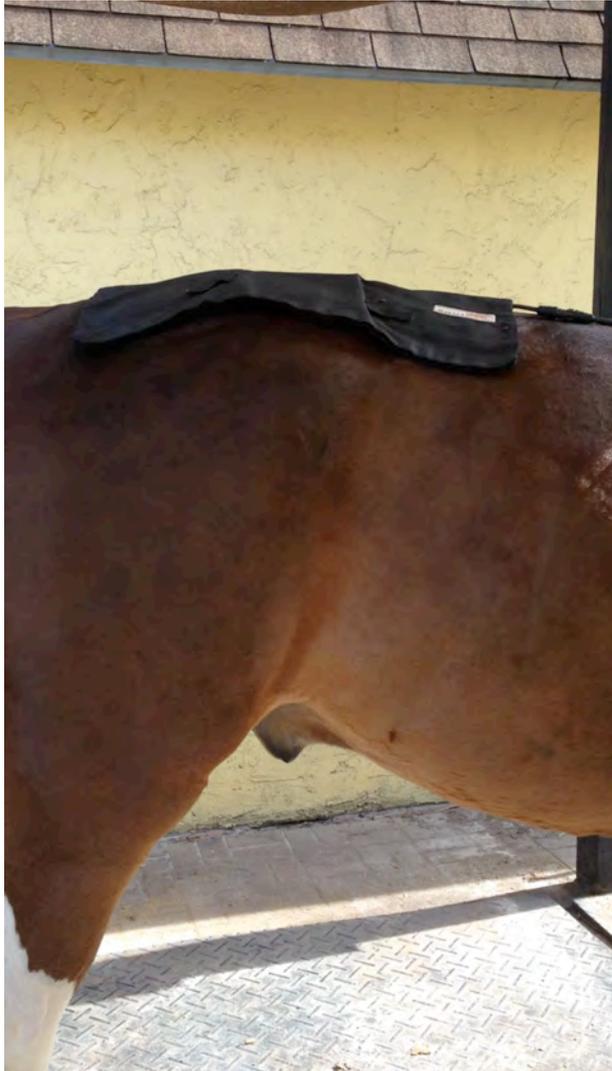


# Post: Single set of lumbosacral and thoracic FES



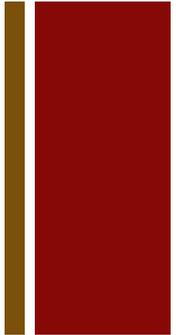
# + Stimulus Timeline FES

Improvement in symmetry of pelvic rotation during a single treatment - reduction in pathological “twist”





# One week between sacrolumbar and thoracic FES



# + Abnormal response to FES



# + FES treatment sequence 35 minutes

5.8 @ 111



6.2 @ 222



7.6 @ 333





**FES EQUINE RESEARCH**

Comparative Exercise Physiology, 2014; 10(2): 89-97

## **Functional electrical stimulation for equine epaxial muscle spasms: retrospective study of 241 clinical cases**

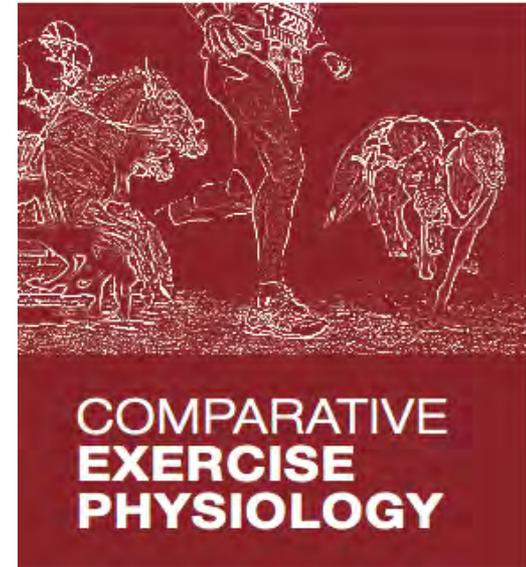
S.J. Schils and T.A. Turner

241 Horses over 13 years

1832 treatments

80% of the horses showed a reduction  
in one grade of muscle hypertonicity with 2 treatments  
Modified Ashworth Scale for horses

60% of those horses showed a sustained improvement for a  
minimum of 2 months



# **Functional electrical stimulation as a safe and effective treatment for equine epaxial muscle spasms**

B Ravara, V Gobbo, U Carraro, L Gelbmann, J Pribyl, S Schils



*European Journal of Translational Myology*  
*Basic Applied Myology - BAM On-Line*

## **Morphometric Analysis:**

- 1) Denervated muscle fibers were present in the Pre and Post-FES biopsies
- 2) Only one horse presented with several long-term denervated muscles fibers Post-FES
- 3) Clinical improvements in reduction of muscle hypertonicity were observed in all horses.
- 4) Preliminary mitochondrial data showed a significant improvement in density to be investigated further

**In conclusion, FES in horses is a safe treatment that provides clinical improvements in equine epaxial muscle spasms.**

# Clinical Results

Pre-FES

Post-FES

Horse  
7003



Horse  
7003





Original Research

**Functional Electrical Stimulation for Equine Muscle Hypertonicity: Histological Changes in Mitochondrial Density and Distribution**



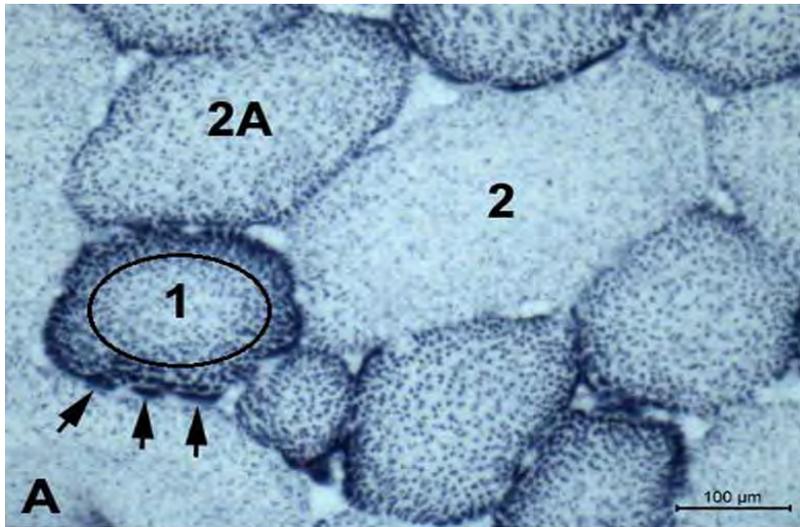
Sheila Schils<sup>a,\*</sup>, Ugo Carraro<sup>b,1</sup>, Tracy Turner<sup>c</sup>, Barbara Ravara<sup>d</sup>, Valerio Gobbo<sup>e</sup>, Helmut Kern<sup>f</sup>, Lin Gelbmann<sup>g</sup>, Jamie Pribyl<sup>h</sup>

Morphometric analyses comparing pre- to post-FES muscle biopsies found:

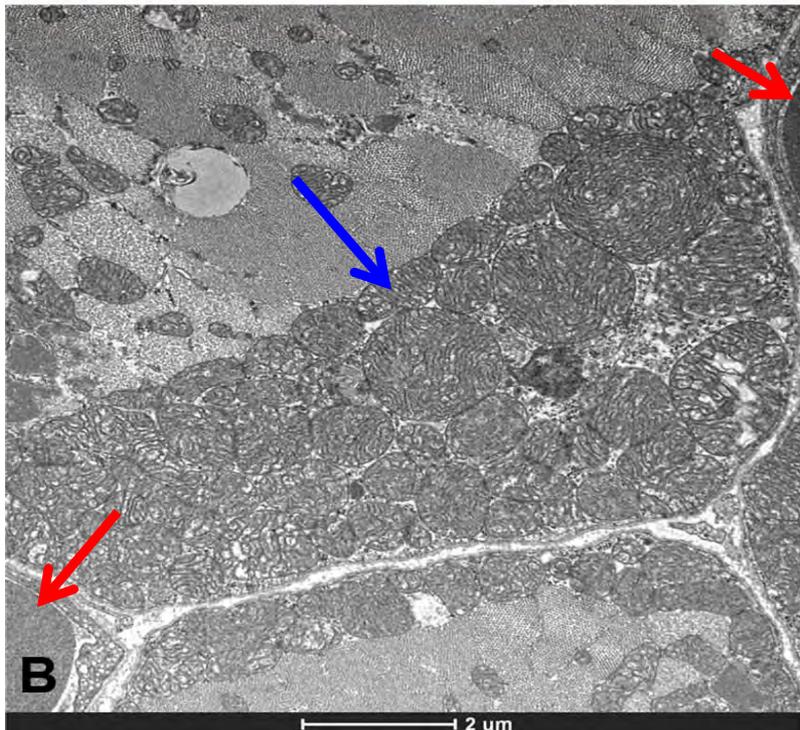
- 1.) Significant increase ( $P < .001$ ) in the pooled mean mitochondrial density of both glycolytic and oxidative muscle fibers
- 2.) Significant increase ( $P < .001$ ) in the subsarcolemmal mitochondrial high-density patches in oxidative muscle fibers
- 3.) Significant increase ( $P < .001$ ) in the subsarcolemmal mitochondrial high-density area percentages in oxidative muscle fibers

**In conclusion, the FES protocol used in this study produced a positive effect on mitochondrial density and distribution, which in turn may help create healthier muscle tissue that is better able to function during exercise.**

# Mitochondrial density and distribution



- A. Type 1 small, oxidative muscle fiber with high-density mitochondria patches (black arrows). The circle defines the central intermyofibrillar area from the coronal high-density mitochondrial area.



- A. Electron microscope image of very-high density mitochondrial patch (blue arrow). The patches are located between 2 capillaries shown with red arrows.

# Preliminary results: Effect of 8 weeks of FES on the symmetry of the multifidus muscles of the horse

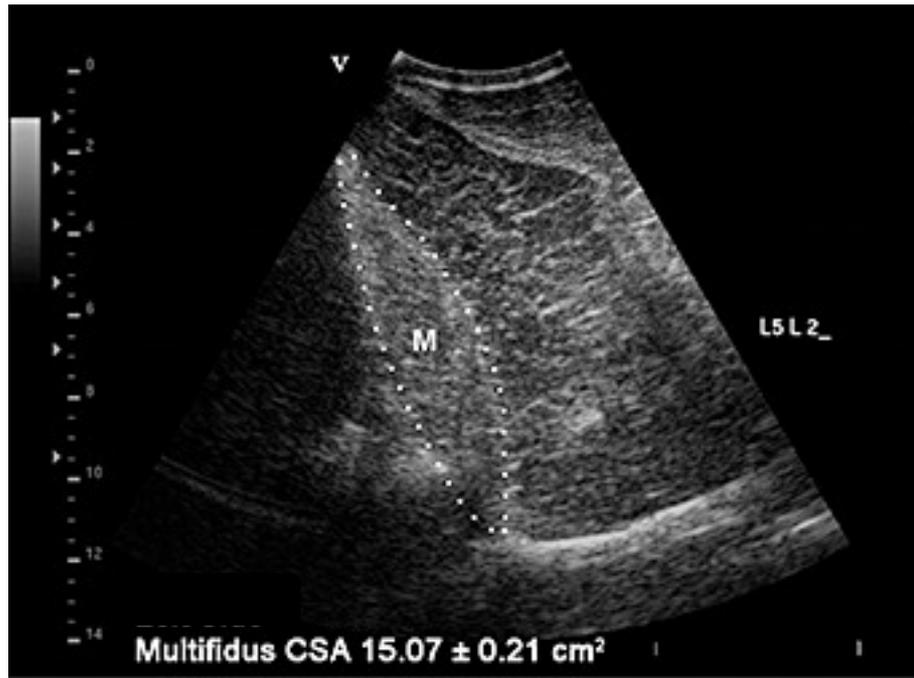


Multifidus at L2

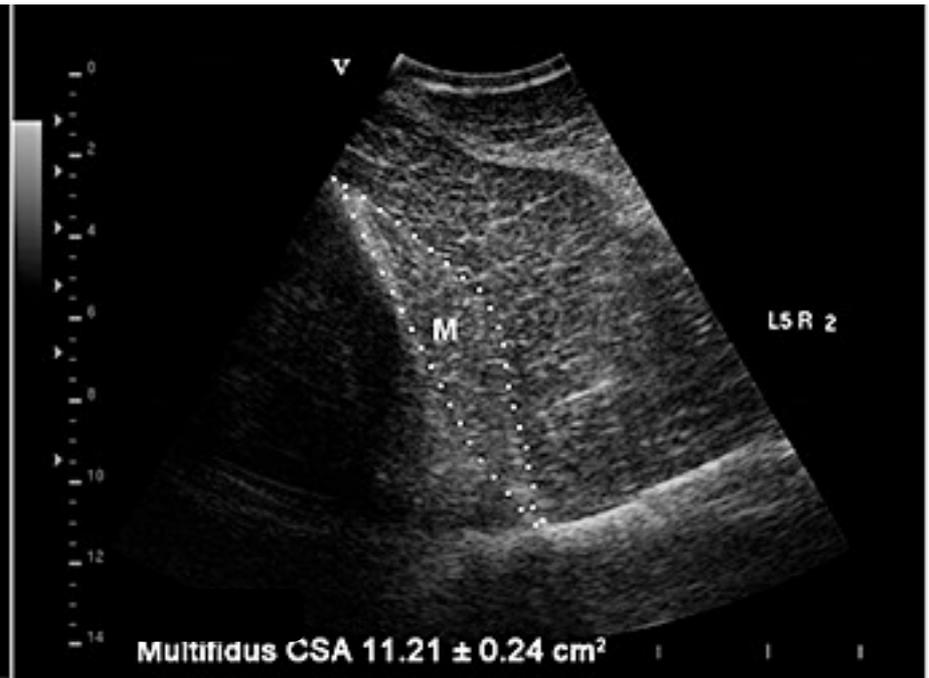


# Ultrasound cross sectional area measurements

■ Post FES



■ Pre FES



# Preliminary results: Effect of 8 weeks of FES on the symmetry of the multifidus muscles of the horse

**TREATMENT GROUP      n=12**

Location	Left average post-pre	Right average post-pre	Symmetry	
				Wilcoxon rank sum test
T10	.63 (p=.21)	.56 (p=.24)		V=54 (p<.01)**
T12	-.38 (p=.55)	-.34 (p=.60)		V=55 (p<.01)**
T14	.14 (p=.79)	.31 (p=.54)		V=50 (p=.02)*
T16	.82 (p=.09)	1.17 (p=.02)*		V=72 (p<.01)**
T18	1.28 (p<.001)***	1.52 (p<.001)***		V=75 (p<.01)**
L2	1.28 (p<.01)**	1.04 (p=.01)*		V=64 (p<.01)**
L4	.78 (p=.02)*	.73 (p=.06)		V=60 (p=.01)*
Overall				<b>V=71 (p&lt;.01)**</b>

# Preliminary results: Effect of 8 weeks of FES on the symmetry of the multifidus muscles of the horse

## CONTROL GROUP n=12

Location	Left average post-pre	Right average post-pre	Symmetry	
				Wilcoxon rank sum test
T10	.63 (p=.46)	.847 (p=.27)		V=9 (p=.47)
T12	.72 (p=.29)	.044 (p=.94)		V=13 (p=.08)
T14	.55 (p=.30)	.671 (p=.24)		V=43 (p=.41)
T16	1.26 (p=.05)	.335 (p=.46)		V=25 (p=.52)
T18	-.25 (p=.57)	.057 (p=.91)		V=34 (p=.97)
L2	-.79 (p=.15)	-.755 (p=.18)		V=36 (p=.85)
L4	-.56 (p=.26)	-.926 (p=.10)		V=53 (p=.30)
Overall				<b>V=43 (p=.79)</b>



# FES EQUINE CASE STUDIES



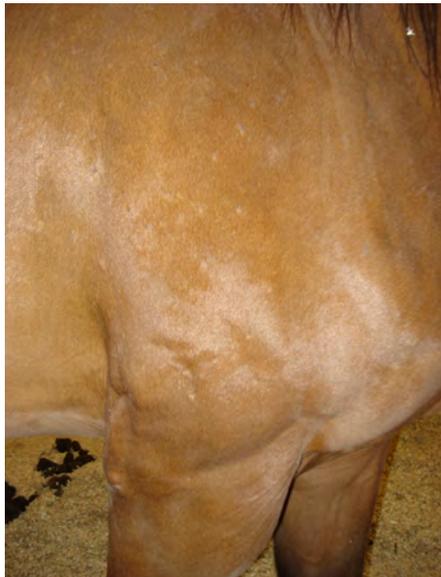
# Case Study – Ulna Fracture Surgery



**Pre Treatment**



**4 FES Treatments**

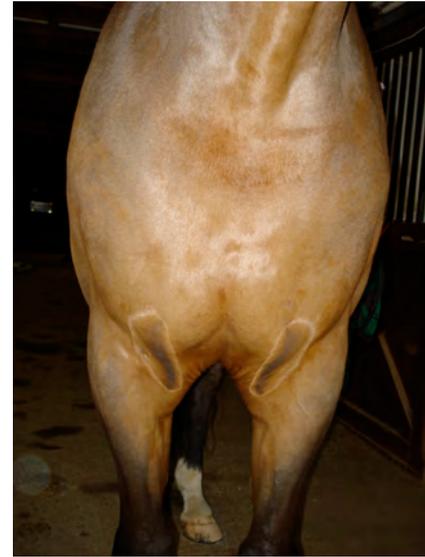


**12 FES Treatments  
over 2 months**



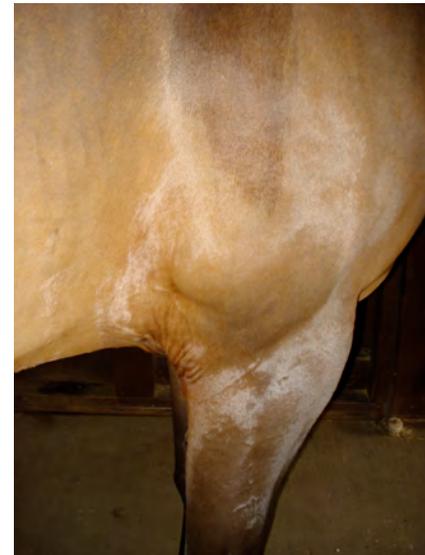


# Shoulder Muscle Atrophy



**Pre  
Treatment**

**5 FES  
Treatments  
Over 3  
months**

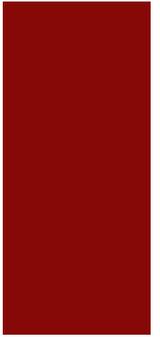


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# Right Shoulder Hypertrophy



**Pre FES**



**Post FES  
7 Tx 3 days**



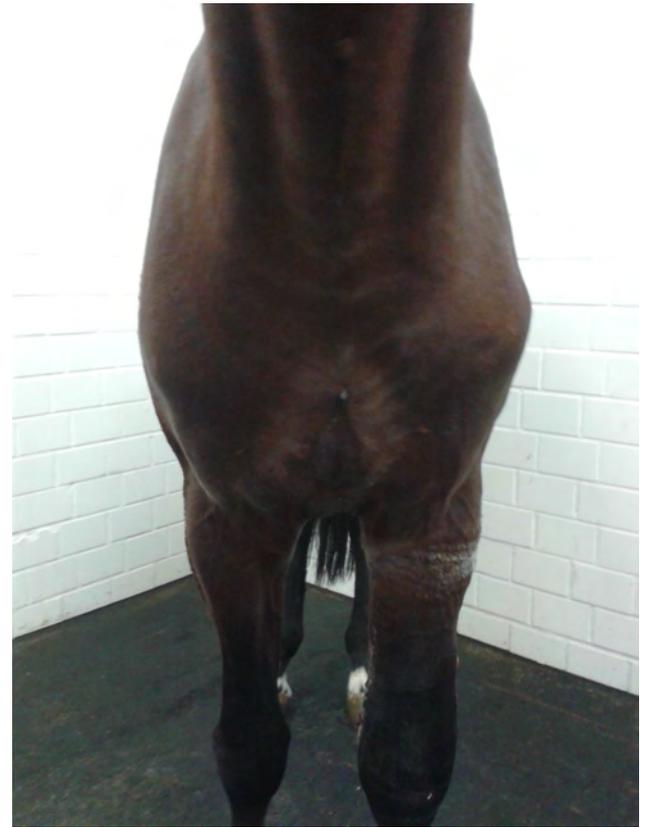
# Left Shoulder Trauma

**Pre FES**



**5 FES  
Treatments  
to Shoulder  
over 9 days**

**Post FES**



+

# Right Hindquarter/Lumbar Muscle Wasting



**Pre FES**



**Post FES  
7 Tx 2 mon**



# + Thorax and Right Hindquarter Muscle Wasting



**Pre FES**



**Post FES  
7 Tx 3 days**



# +Thorax and Left Hindquarter Muscle Wasting

**Pre FES**



**Post FES 4 Tx 4 days**

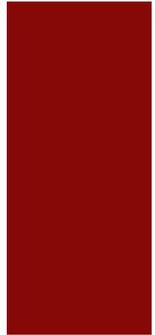


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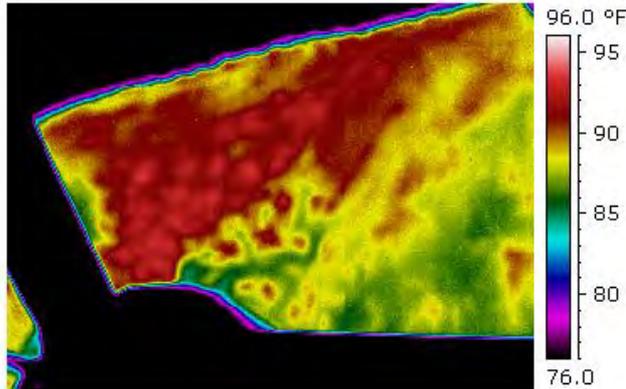
# Bilateral Neck Edema

## 1 FES Treatment

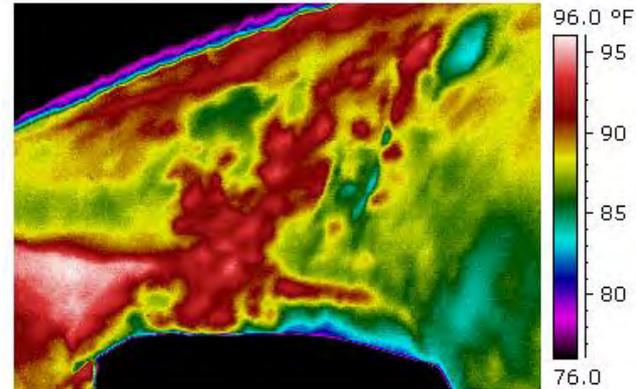
Within 12 hours edema resolved and did not return



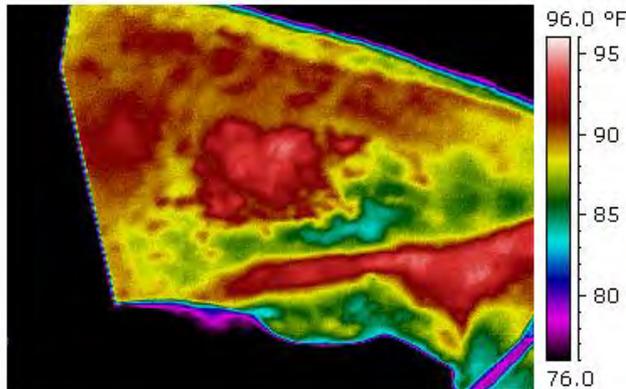
**Left Neck Pre**



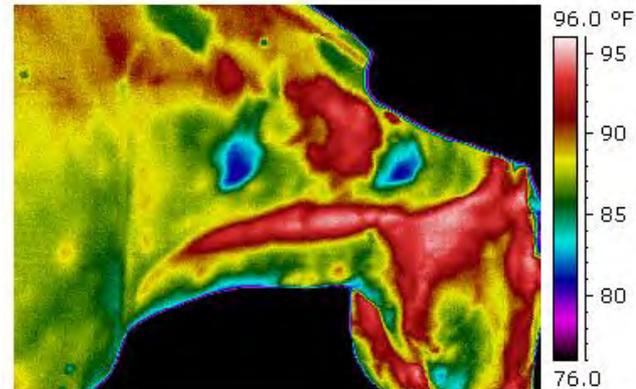
**Left Neck Post**

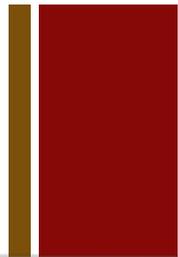


**Right Neck Pre**



**Right Neck Post**





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