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Functional Electrical Stimulation (FES) For Use in Equine Medicine

Take Home Message: Functional electrical stimulation (FES) is a distinct class of electrotherapy that replicates the motor neuron response to produce true muscle contractions. Case studies show the applicability of FES to reverse muscle wasting and decrease muscle spasticity.

Introduction: Functional Electrical Stimulation (FES) is a neuromuscular electrical stimulation (NMES) which replicates the motor neuron response to illicit motor and sensory stimulation. FES produces true muscular movement, which makes it distinctly different from other classes of electrotherapy devices, such as transcutaneous electrical nerve stimulators (TENS), interferential, high-voltage pulsed or galvanic.¹

FES is the most applicable of the electrotherapy devices for use in veterinary medicine due to the stimulation of both sensory and motor neurons and the ability to activate the superficial and deep muscles of the horse. There is high compliance to the treatments even when deep muscles are stimulated due to the production of muscle contractions that feel “normal” to the horse.² Whenever controlled muscular movement would be appropriate for healing or strengthening, FES can be utilized. The purpose of this paper is to review the use of FES as a treatment protocol for equine medicine through the discussion of two case studies.

Materials and Methods: FES is a microprocessor-controlled device, which generates an electrical impulse that is transmitted to surface electrodes. When the intensity of the FES reaches a sufficient level, an action potential is produced in the muscle or nerve resulting in a functional muscle reaction. The ability to produce functional movement is what defines the FES system from all other electrical stimulation modalities. For example, the application of FES to the appropriate muscles of the hand can produce a precise gripping action.

Due to the massiveness of the equine muscular system, when compared to the human, the intensity of the signal is of utmost importance or the deeper muscles of the horse will not be affected. However, at a high intensity the signal must closely replicate the electrical charges of the body so that the treatment is as comfortable as it is effective.

The amount of research available on the use of electrotherapy for human rehabilitation is extensive. The American Physical Therapy Association acknowledges the use of electrotherapy to:

Manage pain

Improve range of motion

Reduce acute and chronic edema

Improve motor control

Improve strength

Reverse muscle wasting

Repair tissue (especially slow to heal wounds)

Improve blood and lymphatic flow³

The FES system can be used with surface electrodes on; groups of muscles and the associated tendons, individual muscles, or “trigger points”, to elicit sensory or motor responses. Joint movement can be produced when stronger muscle contractions are obtained. Electrodes are placed in a pad that is administered to the treatment site, or self-stick electrodes can be used on any part of the body. Avoidance of the brainstem, carotid artery, metal implants and directly over the heart are the main contraindications for horses. The minimum voltage applied is 0.2 volts, and 20 volts is the typical maximum voltage used to produce muscle contractions. The FES system can also be attached to acupuncture needles for use with electroacupuncture.



Pad placement on the back



Pad placement on the leg



Self-stick electrodes

Examples the use of FES in equine medicine is outlined in the following case studies. These cases were selected because they were treated exclusively with the FES modality and have documentation of the treatment progress. The case studies illustrate two benefits of FES; reduction of muscle atrophy, and decrease of muscle spasticity.

Case Study 1. Reduction of muscle atrophy.

Reduction of muscle atrophy in spinal-cord injury patients was one of the original uses of FES in the 1980s. The denervated muscle of para and quadriplegics was stimulated utilizing FES to produce a cycling movement of the legs that resulted in the reduction of muscle wasting. Since that time, many studies have acknowledged the use of FES to reduce muscle atrophy in humans. Research has shown the specific effect of FES treatments on muscle development through the analysis of muscle biopsies. In this study, human subjects were selected who displayed severe myofiber atrophy. With the use of FES stimulation, the muscle biopsies showed decreased muscle atrophy initially, with almost complete reversal if the treatment was continued.⁴ In another study, the quadriceps of spinal-cord injury patients were stimulated utilizing FES. The maximal electrically stimulated torque of the quadriceps increased fivefold during one year of training with FES used 5 days a week.⁵ In humans, FES has been shown to be safe in reducing atrophy and improving muscle strength in even the most fragile muscle tissue, denervated muscle.⁶

The first case study was an ulna fracture that was surgically repaired with a plate. During recovery, a pronounced atrophy of the triceps developed. FES was utilized on the triceps as well as on the top line from T13-L4. The pictures document the change in the musculature after 9 treatments on the shoulder.



Pre Treatment



4 FES Treatments



9 FES Treatments Lateral View



9 FES Treatments Caudal View

Case Study 2. Decrease of muscle spasticity.

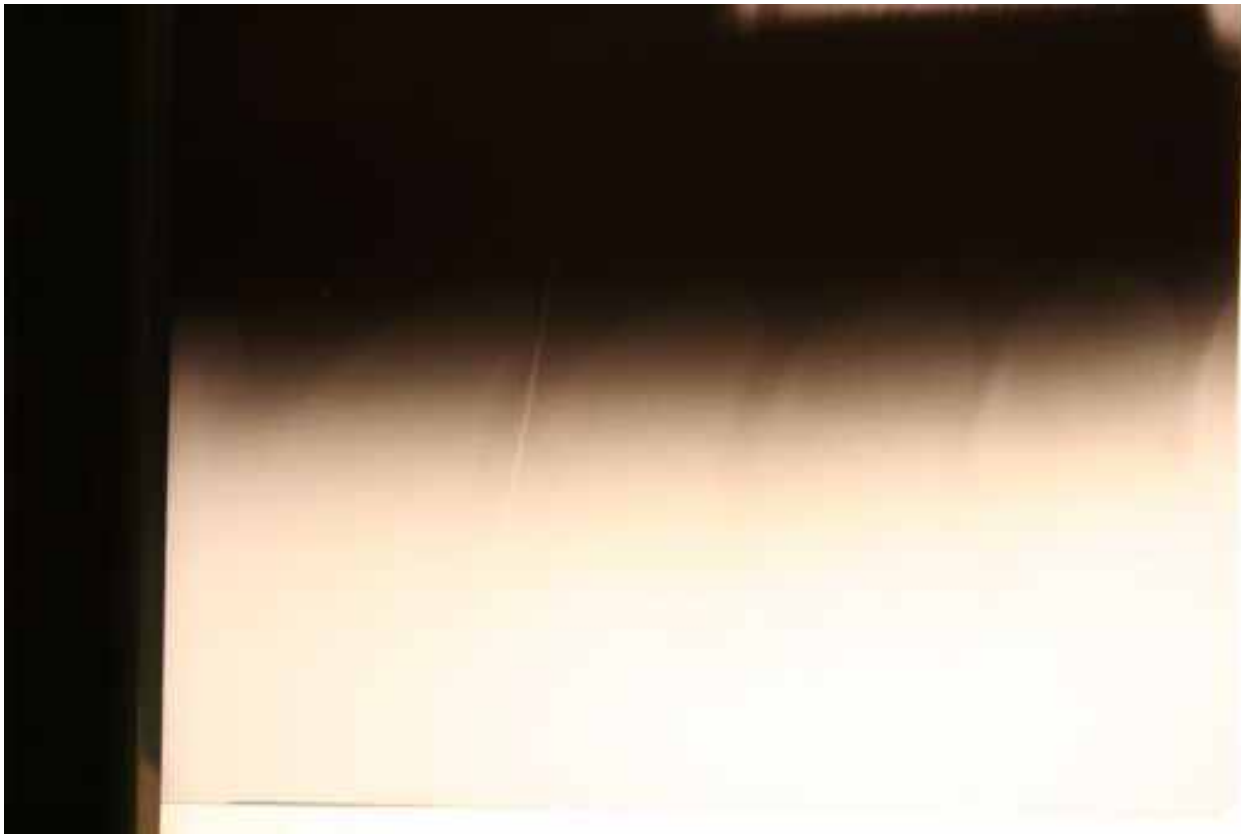
The use of FES to reduce spasticity has been reported in the literature. FES was shown to successfully decrease muscle spasticity related to multiple sclerosis in humans.⁷ In addition, FES was utilized for treatment of long-term spasticity in hemiplegic patients which resulted in reduction of spasticity, as well as an improvement in strength.⁸ Stiffness associated with spastic muscle in spinal-cord injury patients was decreased up to 53% with the conclusion that FES helped reduce abnormal joint stiffness.⁹

The second case study documents the use of FES on a “kissing spine” diagnosis. On 11/13/02 the mare was presented as Grade 4/5 hind limb lameness. At the walk in hand, the mare drug both hind toes and was uncoordinated when turning in small circles. She previously had a successful career as a grand prix jumper. No specific injury was noted, just a progressive decline in performance over the preceding year.

The past history of this case study included 8/7/01 spinal x-rays confirming kissing spine in the posterior thoracic vertebrae. Spinal injections were given at the time of the x-rays. In subsequent months, chiropractic and acupuncture treatments were given. No improvement in performance was noted with any of these treatments.

On 11/13/02 FES treatments were started. Spastic muscles along the top line from T13-L2 were noted as well as spasticity in the gluteal muscle region. The mare was ridden after two FES treatments and the owner noted improvements in the stride length and in the willingness of the mare to move forward.

After 7 treatments, the mare was cantering willingly under saddle and returned to light jumping work of fences under 2'. A total of 17 treatments were given over a period of 5 months. After 5 months of treatments, the mare returned to Grand Prix competition. She was retired 2 years later without any further lameness issues and continues to this day to work as a schoolmaster with no further FES treatments since 2005.



Results and Conclusions: Electrotherapy can be an effective modality for treatment of muscular and associated tendon and ligament injuries in horses, however it is not extensively utilized. In part, this may be due to the fact that the devices and treatment protocols must be modified to suit the specific characteristics of the equine musculature. In addition, practitioners need to become familiar with the differences between electrotherapy devices to select the appropriate modality for application. If the electrotherapy treatment is uncomfortable to the horse, or does not activate the targeted musculature, the full benefits of the modality will not be obtained.

Functional electrical stimulation (FES) is a neuromuscular electrical stimulator (NMES) that has been utilized to produce encouraging rehabilitation outcomes in horses. Case studies documenting the use of FES to reverse muscle atrophy and decrease muscle spasticity show the possible outcomes of the use of FES as a treatment modality. An expanding use of FES in the future will provide even further information regarding the usefulness of electrotherapy in equine medicine.

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