Electrophysical Therapies for the Equine Athlete

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KEYWORDS

• Equine athlete • Electrophysical therapies • Rehabilitation • Treatment

KEY POINTS

- Electrophysical therapies are useful tools for therapy if used at the appropriate time and in the appropriate method.
- Some methods may be harmful to tissues during certain phases of healing.
- There is currently a lack of research in horses to support or reject the use of most of these modalities.

Video content accompanies this article at http://www.vetequine.theclinics.com

INTRODUCTION

Rehabilitation is defined as restoring or bringing an animal to a condition of health or useful and constructive activity. A good rehabilitation program takes into account the possible causes for the injury. Although the specifics of this process can be difficult, the concepts are straightforward. Once the underlying cause of the injury is determined, a veterinarian can construct an appropriate rehabilitation plan and use the available electrophysical therapies to their greatest effect.

The when, how, and for how long of the electrophysical therapies can be simplified by understanding the goals and physical attributes of the modalities and the healing stages of the injured tissue. Most significant injuries have a 30-day inflammatory period, a variable filling-in phase (2–6 months), and then a hugely variable remodeling period (6 months to 2 years). Treating the horse correctly for the type and location of injury, and the stage of rehabilitation of the tissue, helps ensure full rehabilitation success.

From a functional perspective, the goals reflect the healing stages of the tissue. The first goal is to remove pain (inflammatory period). The second is to restore, maintain, or improve range of motion (controlled walking exercise, bodywork, other therapies). The third goal is to restore or improve strength (increased exercise,

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targeted rehabilitation techniques) in the injury and in the overall fitness level of the horse.

This article discusses when and how to use the most common electrophysical therapies in horses including transcutaneous electrical nerve stimulation (TENS), neuromuscular electrical stimulation (NMES), functional electric stimulation (FES), pulsed electromagnetic field therapy (PEMF), therapeutic ultrasound, laser therapy, shockwave therapy, and vibration therapy.

TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION

Origin

The use of electricity for pain relief dates back to a story of an ancient Greek that stepped on an electric fish and noted a significant improvement in his own pain. This led to the development of the "electreat," a machine that was used through the early nineteenth century that used electricity to treat all manner of ailments. In the early 1960s the first portable TENS unit was developed and marketed for in-home pain relief.

Mechanism of Action

Electrostimulation provides pain relief primarily via segmental inhibition through pain gating mechanisms[1] (**Fig. 1**). This relies on activation of larger diameter fibers in peripheral nerves, which in turn helps block nociceptive activity in smaller afferents. Secondarily electric stimulation of peripheral nerves can stimulate a central release of endogenous opiate-like substances, which can have a descending inhibitory effect on pain.[2]

Treatment Protocols

Treatment parameters are based on electrical stimulation in the low-frequency range (<250 Hz) using appropriate pulse durations and intensities to activate the desired nerves. Large-diameter sensory nerves are activated first because of their proximity to the skin surface. Secondarily motor nerves are activated, then nociceptor nerves are affected via the pain gating mechanisms.[1]

Potential Complications

The contacts can cause skin irritation if left on for too long, so care should be taken to inspect the area of treatment regularly for evidence of irritation. Otherwise the modality has minimal complications when used properly.

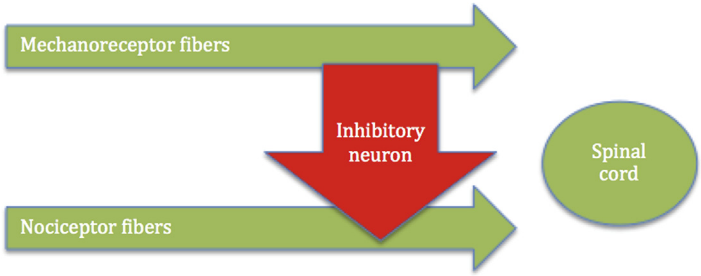

Fig. 1. Gate control theory. Mechanoreceptors can override the nociceptor pain response via presynaptic inhibition.

Indications for Use

- Electrical stimulation for pain modulation (Table 1)
- Acute pain associated with surgery or trauma
- Chronic musculoskeletal pain
- Muscle stimulation through the alpha motor nerve
- Stimulation of de-enervated muscles
- Iontophoresis
- Edema reduction
- Wound healing

Contraindications for Use

- Cardiac issues
- Pregnancy
- Do not use over or through the thoracic cavity
- Fevers or infection

Current Research

There is limited current research into the use of TENS therapy (Fig. 2) in horses. There seems to be some hope for using percutaneous electrical nerve stimulation to ameliorate the symptoms of trigeminally induced head shaking.[3] There is an abundant amount of research to support the use of TENS in humans for a variety of painful conditions.[4] A large portion of the recommendations for equine use is assumed from the human literature. Johnson's[4] book on TENS is a good source for the usefulness of TENS therapy in humans.

Table 1
TENS therapy summarized

TENS Therapy	Sensory TENS	Motor TENS	Noxious TENS
Also called	High-rate TENS	Low-rate or acupuncture-like TENS	Point stimulation
Use in	Any painful condition	Subacute pain or trigger point therapy	—
Avoid in	—	Acute conditions	—
Mechanism of action	Spinal gate mechanism	Descending mechanisms via endogenous opiate release	Central biasing mechanism
Efficacy	Quick relief; short lasting	Longer to effect; longer lasting	—
Nerves targeted	A-beta; large diameter	A-delta; fast pain	C-fiber
Amplitude	Submotor stimulation	Muscle contraction	As high as tolerable
Phase duration	<100 μs	200–300 μs	10–20 ms
Pulse rate	60–120 pps	2–4 pps	2–4 or 100–150 pps
Mode	Continuous/modulation	Continuous mode	—
Length of treatment	20–30 min or continuous	20–30 min	30 s/point; 8–10 points/session
Frequency of treatment	Continuously or intermittently throughout day	Intermittently throughout day	Intermittently throughout day

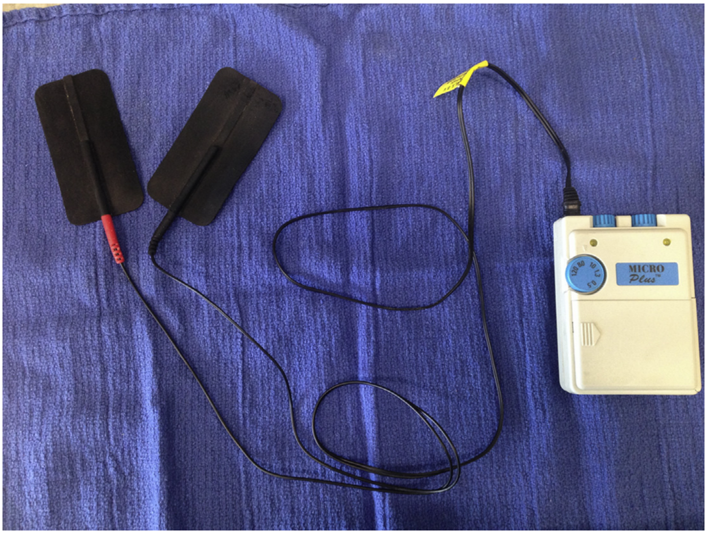

Fig. 2. TENS therapy device. (*Courtesy of* BioMedical Life Systems, Vista, CA; with permission.)

NEUROMUSCULAR ELECTRICAL STIMULATION

Origin

Generated from TENS, the goal of NMES is to achieve full contraction of a much larger muscle belly. The goal of FES is to mimic the pattern of intact nerves. The most commercially available neuromuscular stimulation unit manufactured for horses is the FES unit. NMES was first used in the rehabilitation of patients with spinal cord injury to generate muscle movement.[5] It has been used to prevent atrophy of de-enervated muscles and for a large range of nerve and muscle conditions to decrease pain or atrophy and improve function. The FES unit (**Fig. 3**, Video 1) has been adapted to provide pain relief and support for the equine athlete in training.

Fig. 3. FES machine set up to treat cervical region. (Equinew, LLC, Rivers Falls, WI.)

Mechanism of Action

Using the same electrical stimulation as the TENS unit the NMES machines use a longer pulse duration (width; 200–600 μs), variable amplitude needed to achieve muscle contraction, and a frequency of more than 50 Hz.

Treatment Protocols

The treatment goal is to achieve muscle contraction; therefore, proper placement of the electrodes and increasing the amplitude to effect is an effective way of constructing a treatment plan. The intensity should be what the animal can tolerate; the number of repetitions should start low (8–15 contractions per session) and increase to more than 3 to 5 weeks with one to five sessions per week depending on the treatment goal and injury.[5]

Potential Complications

Some horses are intolerant of the procedure. The same skin irritation can occur as with the TENS unit but less commonly because the treatment length is usually shorter.

Indications for Use

- Electrical stimulation for pain modulation (**Table 2**)
  - Acute pain associated with surgery or trauma
  - Chronic musculoskeletal pain
- Muscle stimulation through the alpha motor nerve
- Stimulation of de-enervated muscles
- Removal of edema

Contraindications for Use

- Cardiac issues
- Pregnancy
- Do not use over or through the thoracic cavity
- Fevers or infection

Current Research

Similar to the TENS research most research into neuromuscular electrical stimulation has been in humans. In horses FES (**Table 3**) has been shown to improve epaxial muscular contraction over time and to decrease muscle spasm.[6] There is minimal research apart from case studies and anecdotal evidence.

The human research has been wide ranging. In humans FES has been shown to help improve reaching and grasping functions,[7] and to reverse muscle atrophy in de-enervated muscle tissue.[8] Contrary to many claims there is also research showing that a good physical therapy program is effective with or without the addition of NMES for patellar femoral pain syndrome.[9]

ELECTROMAGNETIC ENERGY: PULSED ELECTROMAGNETIC FIELD THERAPY

Origin

The ancient Greek *magnes lithos* meaning, “stone from Magnesia,” is the origin of the word “magnet.” There is a larger percentage of the mineral magnetite in the rocks in the area of Magnesia. Magnetic stones were advocated to be therapeutic in ancient Chinese texts. Electrical generation of a magnetic wave was first proved in the time of Albert Einstein.[10] Modern electromagnetic field therapy started in 1971 when Friedenberg and coworkers[11] described the healing success of direct current

Table 2
TENS/NMES treatment parameters

Nerve Type	Characteristics	Examples	Phase Duration	Amplitude	Frequency
Aα	Motor fibers Diameter 13–20 μm Speed 80–120 ms^{-1}	Muscle spindle cells (primary) Golgi tendon organs Mechanoreceptors	250 μs	Sufficient to produce mm contractions	>50 pps
Aβ	Sensory fibers Low threshold Diameter 6–12 μm Speed 35–75 ms^{-1}	Mechanoreceptors Proprioceptors Muscle spindle cells (secondary)	<150 μs	Submotor	60–120 pps
Aδ	Sensory fibers High threshold Diameter 1–5 μm Speed 5–35 ms^{-1}	Mechanoreceptors Cold sensitive Nociceptors	200–300 μs	Strong muscle contractions	<10 pps
C	Sensory fibers Diameter <1.5 μm Speed <2 ms^{-1}	Nociceptors Mechanoreceptors Cold and heat sensitive	>300 ms	Pain response	<20 pps OR >100 pps
Muscle membrane	Stimulation of de-enervated muscle	—	n/a; direct current	n/a; direct current	≤5 mA
Sympathetic fibers	Microcurrent	—	Variable	Subsensory	Variable

Table 3
FES treatment protocols

Clinical Condition	Treatment Frequency	Length of Treatment
Thoracic/lumbar/sacral pain	2 within 28 h 3 within 3 wk 6 within 1 y	Variable; response to treatment
Kissing spine	2 within 48 h 3 within 3 wk 12 within 1 y	Variable; response to treatment
Muscle atrophy	2 within 48 h 3 within 3 wk 6 within 1 y	Until return to full function
Limb edema	2 within 48 h 3 within 3 wk 6 within 1 y	Until resolution of edema
Tendonopathy	2 within 48 h 3 within 3 wk 4–12 within 1 y	One year
Suspensory desmopathy	2 within 48 h 3 within 3 wk 4–12 within 1 y	One year or more

Data from Schils S. Equinew user manual (manual that came with FES machine). 2014.

delivered to a nonunion fracture. To be less invasive Bassett and coworkers[12] at Columbia University in the mid-1970s developed a protocol using low-frequency electromagnetic signals. Goodman and coworkers[13] also showed that there were changes occurring at the cellular level, but that these were not happening until 45 minutes of exposure to the waves.

Mechanism of Action

The therapeutic generation of local heat by high-frequency electromagnetic waves is called diathermy. The waves are generated as an electrical current is driven through a coiled wire. The magnetic field creates small currents inside the tissues. The greatest heating occurs in tissue with low impedance, such as muscles. Pulsed diathermy can raise temperatures of deeper tissues by 3°C to 4°C.[14] PEMF is a lower frequency and is derived from this heat-generating therapy (**Fig. 4**). Short wave diathermy can be adjusted to a low frequency (less than 600 pps) and short phase duration (65 s). This magnetic field results in currents within the tissues but no heating inside the tissues.

In the equine world there are several therapeutic options available for PEMF therapy. There are blankets and wraps with coils and energy-generating battery units built into them.[15] There are small coil systems[16] and large coil systems,[17] which produce the magnetic field in different sizes and strengths.

Treatment Protocols

The treatment protocols vary significantly in the literature and seem to be specific to the type and manufacturer of the machine used. They are based on the frequency of the pulses and the treatment time.

Fig. 4. Small PEMF machine. (*Courtesy of* Magna Wave PEMF, Louisville, KY; with permission.)

Potential Complications

There are minimal documented side effects from PEMF treatments.

Indications for Use

- Stimulate bone healing
- Increase blood flow in superficial and deep tissues
- Decrease pain and muscle spasm

Contraindications for Use

- Application over any implants
- Pregnancy
- Open wounds
- Cancer
- Infection
- Acute inflammation and joint effusion

Current Research

The strongest evidence for efficacy with PEMF lies with nonunion or slow to heal fractures (Table 4). There does not seem to be significant evidence to support soft tissue uses of PEMF in the horse or in humans.

Table 4 depicts the wide range of treatment parameters that have been researched in other species each of which has shown to have a positive effect on bone healing. However, in the 1980s in horses there was a study that showed no improvement in healing of osteotomies in groups treated with electromagnetic devices compared with control animals.[18]

Table 4
Treatment parameters for PEMF for bone healing

	Frequency	Treatment Time	Length of Treatment
Bone healing in dogs[19]	1.5 Hz	1 h/d	8 wk
Delayed union[20]	15 Hz	3 h/d	—
Nonunion fracture[21]	7.5 Hz	8 h/d	30 d
Decreased pain postfracture	50 Hz	30 min/d	—

THERAPEUTIC ULTRASOUND

Origin

In the early twentieth century, following the tragic sinking of the Titanic, research began on the use of sound waves to identify objects. During the early phases, it was found to have detrimental effects on marine life, which led to its use in live tissues as a medical therapy. The first recorded use was in 1938 on a human suffering from sciatica.[22]

Mechanism of Action

Unlike diagnostic ultrasound, therapeutic ultrasound (**Fig. 5**) is designed specifically to have a biologic effect on the tissues. The ultrasound uses cyclic vibration frequencies of 1 to 3 MHz, and the mechanical energy produced makes for a wave of acoustic energy, which is inaudible to the human ear. This energy travels through tissues and is absorbed by the deep tissues via molecular vibration, without altering the temperature of the skin surface.[5]

- Good penetration while maintaining tissue selectivity
- Increases in temperature, which provides cellular energy
- Increased cellular metabolism
- Increased oxygen demand
- Causes vasodilation
- Allows inflammatory components to infiltrate the region
- Mast cells become activated and degranulate
- Triggers the arachidonic acid cascade developing a proinflammatory state[23]

Used during the proliferative phase of healing, therapeutic ultrasound can upregulate fibroblastic activity and increase protein and collagen synthesis via release of growth factors.[24]

In the remodeling phase of tendon and ligament healing, ultrasound can increase the tensile strength of collagen, improving the fiber pattern and orientation as it assists

Fig. 5. Therapeutic ultrasound machine (DynaPacific Dynatronics Livermore Operation, CL, USA) in use on a bilateral deep digital flexor desmotomy.

in the transition from type 3 to type 1 collagen.[25] Therapeutic ultrasound frequencies are well absorbed from high-protein tissues, and minimally absorbed by tissues high in water content.

Cartilage and bone, although high in protein, reflect the ultrasound waves, so this therapy has no effect on these tissues.[26] Therapeutic ultrasound also has an analgesic effect likely via decreased local nerve conduction and the release of endorphins and serotonin.

There are also nonthermal effects of therapeutic ultrasound. This is via the cavitation that occurs from mechanical vibration energy that forms tiny gas bubbles that improve the acoustic streaming, therefore altering cellular diffusion and permeability. Sodium and calcium ion transport channels are most affected altering the membrane potential and cellular secretions.[27]

Therapeutic ultrasound is used in two different modes: pulsed and continuous. The pulsed mode provides nonthermal effects, such as cavitation and mechanical effects, whereas the continuous mode provides the thermal effects on the tissue.[28] Therapeutic ultrasound does not have a cumulative effect in treatment, meaning the tissue temperatures do not remain elevated for longer than the treatment itself (**Fig. 6**). A 1° increase in temperature triggers metabolic activity, 2° to 3° with decrease muscle spasms and increase blood flow, and 4° with change the viscoelastic properties of collagen.[5] The specific settings depend on the machine, but often treatments are started on a daily basis for up to 7 to 10 days then decreased to a few days per week until the desired effect is noted.

Potential Complications

There is a narrow window of temperature range, which can make use challenging and potentially risky. The ideal temperature for use is 40°C (104°F), but above 45°C (113°F) can cause tissue damage. The machines require maintenance and calibration to maintain appropriate temperatures. The ultrasound does not work through air, and therefore requires a clean patient, copious gel, and good transducer contact. Clipping the hair further improves the contact.[29]

Indications for Use

- Tendon and ligament: minimizes contraction with healing
- Fascial planes
- Joint capsule: improves range of motion
- Scar tissue: softens scar tissue
- Osteophytes/enthesiophytes: decreases pain; however, no effect on bone itself
- Muscle spasms: slows gamma fiber transmission
- Wounds: increases protein synthesis in fibroblasts (use 2 weeks postinjury)

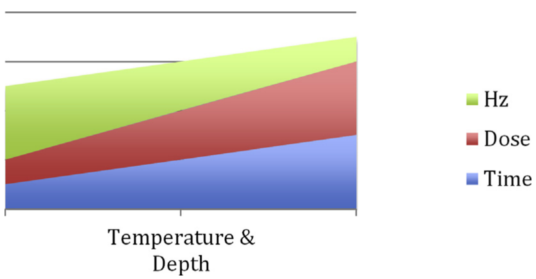

Fig. 6. Temperature versus depth chart for therapeutic ultrasound.

- Edema: reduces tissue edema[22]
- Nerve injuries: remyelination and regeneration of damaged axons[30]

Contraindications for Use

- Ophthalmic use: poor vascularization of lens causes intolerance to heat
- Pregnant mares: specifically over reproductive regions
- Cardiac: potential for electrical disruption
- Growth plates: potential for developmental abnormalities
- Fractures: may delay healing process
- Hindered sensation, such as nerve blocked locations
- Vascular insufficiency
- Thrombophlebitis/clotting dysfunction: potential for emboli
- Infection/cellulitis: potential for spread of infection via vasodilation
- Malignancy: potential for spread
- Immediately after exercise: tissues already at high temperature[22]

Current Research

A recent study on the thermal effects of ultrasound treated both the superficial and deep digital flexor tendons with a 3.3-MHz continuous ultrasound for 10 minutes at an intensity of 1.0 W/cm^2. This led to an approximate increase in temperature of 3°F to 7°F in the flexor tendon tissue. However, at the same settings of 3.3 MHz and 1.0 W/cm^2, there is no change in temperature detected in the epaxial muscles along the spine.[31]

In canines, a study looked at Achilles tendon injuries and found that those dogs treated with therapeutic ultrasound (0.5 W/cm^2) had improved tendon healing and their return to soundness was more rapid compared with those without therapeutic ultrasound.[32]

Therapeutic ultrasound has also been tested in the treatment of induced septic arthritis in donkeys, and those treated with ultrasound therapy had less changes to the joint capsule, synovium, and articular cartilage.[33]

EXTRACORPOREAL SHOCKWAVE THERAPY

Origin

Shockwave (extracorporeal shockwave therapy [ESWT]) has been used in medicine to break up ureteral stones in humans, but was not used in equine orthopedics until 1996, when a German veterinarian used it to treat suspensory desmitis.[34] At the time, the machines were very large and general anesthesia was required for equine patients.

Mechanism of Action

Shockwave (**Fig. 7**) uses pressure waves that increase as they travel through tissues. The pressure change leads to cavitation, and the formation and collapse of tiny gas

Fig. 7. Shockwave therapy being applied to medial distal interphalangeal joint collateral ligament.

bubbles, which leads to microtrauma of the tissues. This microtrauma is beneficial to the injured tissue in that it leads to neovascularization and therefore increased blood flow to the area. The increased blood blow allows for introduction of inflammatory cells and nutrients. Shockwave also has analgesic effects, which peak approximately 48 hours after treatment, this should be taken into consideration because this has the potential to mask the patient's pain level, which can be risky in the rehabilitating horse.[35]

Treatment Protocols

- Focal energy used (probe type) (Table 5)
- Number of pulses effect on tissues
- Upper limit where unwanted tissue damage can occur
- There is not a set range for these limits because they depend on
  - Patient's size
  - Location of the affected tissue
  - Individual machine

Shockwave is a therapy that uses the three-dimensional conformation of a patient and therefore the administrator must work from all angles on the affected area. Protocols for use generally require three to six treatments at 2- to 3-week intervals. Too frequent of use does not allow the body to react and initiate healing from the microtrauma that is produced.

- Good tissue contact is required, which may mean clipping hair, cleaning the area, and lots of ultrasound gel
- Shockwaves do not penetrate the hoof wall, sole, through a cast, or through an air interface

Table 5
Standard treatment protocols for ESWT

Location	# of Pulses	Energy Flux	Results
Fourth metatarsal bone stress fracture/exostosis	2000	.15 m/mm^2	Increased exostosis
Tendon/ligament injury	600	.14 m/mm^2	Increased Glycosaminoglycans Increase protein synthesis
Forelimb proximal suspensory desmitis	2000	.15 m/mm^2	Increased intracellular matrix
Superficial digital flexor tendonitis	—	—	Faster healing Increased vascularization
Osteoarthritis of hock joints	2000	.89 m/mm^2	Decreased protein in synovial fluid Improved lameness
Navicular syndrome (through frog between heel bulbs)	1000/1000	.89 m/mm^2	56% improved one lameness grade
Collateral ligament of distal interphalangeal joint	—	—	No significant improvement compared with rest/controlled exercise
Back pain (bone sclerosis)	50 pulses/cm^2	.15 m/mm^2	—
Back pain (muscular)	100 pulses, trigger points	.15 m/mm^2	—

- There seems to be better efficacy for shockwave therapy on the front limbs compared with the hind limbs[36–38]
- Shockwaves generally penetrate a maximum of 50 to 110 mm, thus making deeper structures, such as the sacroiliac joint, out of their treatment range[39]
- Shockwave treatment of collateral ligaments of the distal interphalangeal joints is not positively correlated with outcomes[40]

Potential Complications

It is rare, but with overuse, tissues can become overheated. Swelling has been seen at the affected site posttreatment. There is potential for development of white hairs over the treated area. Treatment on bone has the potential to exacerbate microfracture damage with excessive numbers of pulses used. Shockwave does not function through an air interface, such as the thoracic cavity, and reflects, which has the potential to lead to hemorrhage. Good tissue contact is required, which means clipping hair, cleaning the region, and copious amounts of gel.

Indications for Use

- Tendon/ligament injuries or desmitis/tendonitis: rapid healing, improved fiber pattern, matures collagen fibers
- Bone (including stress fractures, exostoses, osteoarthritis): osteogenic stimulation and remodeling
- Nonhealing fractures: improve callus formation
- Periostitis
- Back pain
- Frog: can penetrate hoof through frog if treating distal phalanx

Contraindications for Use

- Young, growing animals: can lead to premature closure of physes

Current Research

Most of the current research on ESWT entails experimentally induced tendon and ligament injuries, such as forelimb and hindlimb suspensory ligament desmitis via the introduction of collagenases into the tissues. The studies on forelimbs and hindlimbs showed the limbs treated with ESWT had more collagen fibril formation, increased growth factors (transforming growth factor-β), and increased proteoglycan deposition. Ultrasonographically, the lesions showed improved healing with less hypoechogenicity and smaller lesion size.[41,42] Shockwave therapy also was seen to decrease the degree of lameness seen in these horses. This is likely caused by a period of analgesia that occurs approximately 4 days post-ESWT treatment. Because of this analgesic effect of shock wave therapy, both the federation equestre internationale and Racing Jurisdiction of the United States have implemented regulations regarding specific withdrawal times before competition. There has also been research on the effects of ESWT on bone pathology. A study using arthroscopically induced osteoarthritis of the middle carpal joint in horses found that those treated with ESWT had no evidence of adverse effects and lameness was visibly improved. Shockwave did not show direct evidence of benefits to the synovial fluid or tissue or the associated articular cartilage of the arthritic joint.[34,43]

LASER THERAPY

Origin

Laser therapy has been in use for more than 30 years, and has really taken off in the veterinary field for small and large animals in the last 10 years. Laser has similar benefits as acupuncture, but without the invasiveness of the needles, and is often used on similar trigger points.[44]

Mechanism of Action

There are four classes of lasers, with the class IV laser (Fig. 8) being the most common choice for equine practice. These low-level lasers work in a range less than 500 mW, and the wavelengths vary from 540 nm to 1060 nm. Laser therapy, similarly to therapeutic ultrasound and shockwave, has anti-inflammatory and analgesic effects.

- Stimulates cellular metabolism
- Direct activation of mitochondrial calcium channels
- Upregulation of ATP production and synthesis
- Increases fibroblastic activity[45]
- Increased cellular division, fibroblast migration, and production of cellular matrix[45]

More specifically, it has been shown that prostaglandin E_2, tumor necrosis factor-α, interleukin-1β, plasminogen activator, and cyclooxygenase-1 and -2 are all manipulated with the use of laser therapy, producing a decrease in inflammation.[46] The anti-inflammatory effect is via stimulation of prostaglandins leading to vasodilation.[47]

Laser therapy is beneficial on wounds and tendon and ligament injuries, because it increases cellular proliferation and collagen synthesis leading to more rapid healing of the damaged tissue. Laser therapy works synergistically with platelet-rich plasma treatments to increase recovery time in tendon and ligament injuries, such as tenosynovitis and synovitis. Not only has laser therapy been shown to accelerate healing, but it can also be used to maintain optimum performance, and prevent recurrence of injury.[15]

Fig. 8. Laser therapy for a superficial digital flexor injury.

The effects of laser therapy on bone are partially unknown; however, there have been several studies showing benefits in dental procedures in humans, leading to bone repair and regeneration.[45]

Treatment Protocols

Proper use of low-level laser therapy depends on the machine used. Considerations are wavelength, pulse frequency, and time of application. If not used properly the tissues can overheat so it is important to follow product labels and directions. Laser can be used on a daily, weekly, or monthly basis for treatment and/or prevention. Often for injuries treatments begin daily then decrease over time depending on response to treatment.[48] A study on the use of laser therapy on wound healing treated the wound every other day for 80 days with great results. Treatment time varies based on location and purpose of treatment and wavelength and power of the machine. Generally the treatment time varies from 5 to 30 minutes.[49]

Potential Complications

Other than the previously mentioned contraindications, potential concerns with laser therapy include overheating the tissues with overuse or incorrect use. Care should be taken to follow the appropriate machine indications and protocols. Another concern with the use of laser therapy is damage to both the patient's and the administrator's cornea. Protective eyewear should be worn when performing laser therapy, and eye shields should be placed on the horse if the treatment is in the head or neck region.

Indications for Use

- Performance maintenance
- Prevention of injury recurrence
- Synergistic with stem cell and platelet-rich plasma treatment
- Tendon and ligament injury
- Chronic joint disease
- Synovitis
- Osteoarthritis
- Back pain/injury
- Wound healing
- Pain relief
- Neurologic injuries
- Alternative to acupuncture/acupressure

Contraindications for Use

- Pregnant mares (unknown effect)
- Young, growing animals (unknown effect on physes)
- Malignancy
- Hematologic disorders
- Febrile patients
- Ocular use

Current Research

There is growing research on the effects of laser therapy on wound healing. There is conflicting evidence regarding the effect of laser on second-intent wound healing, because some studies have shown no significant differences in epithelialization or wound contraction.[50] Another study looking at two horses with septic wounds found that laser therapy stimulated fibroblastic formation and collagen synthesis.[51] In studies in species other than equine, histologic responses to low-level laser therapy have indicated a reduction in inflammation, reduction in edema, and increased collagen synthesis.[52] Further research on the efficacy of laser therapy on wound treatment is needed because of the varied results.

Low-level laser therapy is regularly used as a treatment modality for tendon and ligament damage. Minimal research has been done in equines in terms of effects on tendon and ligaments and joints and cartilage. A study done in rodents with collagenase-induced Achilles tendonitis showed reduction in matrix metalloproteases and improvement in the mechanical properties of the tendon.[46] Chemically induced osteoarthritis in rabbits treated with laser therapy indicated cartilage regeneration and chondrocyte replacement.[53] Both of these studies provide promising evidence that similar effects may occur in our equine patients.

VIBRATION THERAPY

Origin

Vibration plates (**Fig. 9**) were first developed for humans in the 1990s for treatment of osteoporosis. The plates were first developed for astronauts as a way to prevent osteoporosis and muscle wasting in the absence of gravity.

Mechanism of Action

Vibration plates provide mechanical energy in the vertical and/or horizontal direction, and the amplitude of the motion and speed of acceleration determine the ultimate magnitude of the vibration produced.[54] Vertical vibration more closely mimics the natural movement of the horse. Vibration plates are thought to improve circulation of the cardiovascular and lymphatic systems, via continuous involuntary muscle contractions (30–50 per second). Benefits of improving circulation include enhanced oxygenation of tissues, removal of toxic and metabolic waste, and introduction of cells as part of the inflammatory cascade.[55] Vibration plates also promote joint stability to some degree in that they directly stimulate and strengthen the associated muscles,

Fig. 9. Core exercises on a vibration plate.

such as in the human knee or equine stifle joint.[56] In humans, vibration plates have been used to assist in counteracting osteoporosis; however, results in horses have shown minimal to no osteoblastic activity.[57] Vibration plates also provide general feelings of well-being in that it has been shown to stimulate production of the neurotransmitter serotonin and decrease serum cortisol with low-intensity whole-body vibration.[57,58] Moderate to high intensity vibration behaves like extensive exercise, however, and increases creatinine kinase levels indicating muscle breakdown and elevated lactate levels caused by anaerobic metabolism.[59]

Treatment Protocols

Little research has been done on specific treatment protocols for the use of the various types of whole-body vibration plates. Anecdotally, they have been used on a daily basis in healthy animals with no ill effects. Sessions generally last 10 to 15 minutes, but should be modified based on the specific brand recommendations. It is suspected that pulsed treatment as opposed to continued vibration may have better osteogenic stimulation. In humans, frequencies in the range of 25 to 45 Hz led to improved muscle strength and an increase in muscle size.[54]

Potential Complications

The potential effects of whole-body vibration on a patient with any form of internal fixation are unknown and therefore should be avoided until further research has been conducted. Not all horses tolerate the vibration plate and, therefore, do not make good candidates for its use.

Indications for Use

- Tendon and ligament injuries
- Maintenance of fitness
- To promote blood flow
- Postoperative strength training (depending on surgery)

Contraindications for Use

- Acute fractures

Current Research

A 2013 study measured general clinical parameters in seven horses following 10 minutes of whole-body vibration exercise at a frequency of 25 to 21 Hz. The study found no measurable ill effects or signs of discomfort from the horses, in that their serum cortisol levels and creatinine kinase levels were significantly lowered following the treatment. No other clinical parameters were changed following the use of the vibration plate, including bone markers, suggesting there are no osteoblastic effects of vibration in horses.[57] A 2009 study in humans, however, showed significant osteogenesis and increased fluid flow through the extracellular spaces in bone and lacunae as a result of the loading forces from the vibration plate.[54] The same paper also showed a noticeable increase in testosterone levels, and this particular hormone is known to promote bone mineral density in humans. Similarly, growth hormone levels also increase with exercise and are suspected to also be elevated with vibration plate activation subsequently promoting osteogenesis.[54]

SUMMARY

Electrophysical therapies is an evolving field of rehabilitation that is growing faster than the scientific community can keep up (**Table 6**). These machines are manufactured by

Table 6
Summary of modalities

Appropriate Use of Modality During Healing Phases							
	TENS	NMES	PEMF	EWST	Laser	Therapeutic US	Vibration Therapy
Inflammatory	x	—	—	x	x	x	—
Filling in	x	x	—	x	x	x	x
Remodeling	x	x	x	x	—	—	x

Appropriate Use of Modalities for Specific Conditions							
Condition/Therapy	TENS	NMES/FES	PEMF	Therapeutic US	ESWT	Laser	Vibration Therapy
Arthritis	x	x	x	x	X	x	x
Back soreness	x	x	x	x	X	x	x
Cellulitis	x	x	—	—	—	x	—
Colic recovery	x	x	x	x	X	x	—
Hoof injuries	—	—	—	—	x(frog)	—	—
Acute laminitis	—	—	—	—	—	—	—
Chronic laminitis	—	—	—	—	—	—	—
Tendon and ligament injury	x	x	x	x	x	x	x
Muscle injury	x	x	x	x	—	x	x
Muscle soreness	x	x	x	x	x	x	x
Neurologic disease	x	x	—	—	—	x	—
Postsurgery recovery	x	—	—	x	—	x	—
Scar tissue/adhesions	x	x	x	x	x	x	—
Wounds	x	—	—	X (2 wk post)	x	x	—
Skin infections	x	—	—	—	—	—	—

many different companies in different places with a huge variation on quality and little to no safety oversight. Minimal peer-reviewed scientific studies are available; therefore, anecdotal evidence and case studies make up most of their claims of efficacy. The Internet is accessible to the horse owner, so it is easy to get a new technology out to the market. It seems proving the efficacy of the modality can be as simple as one good review by an Olympic champion on social media. This is not an ideal situation, because the veterinary community is falling behind the curve of knowledge. This article is not an exhaustive list of the electrophysical therapies available for equine rehabilitation today (an ever growing and expanding field). Future editions of this article may list some very different topics. It is hoped that time and more peer-reviewed research will provide more realistic expectations of treatment outcomes to discuss with our owners.

SUPPLEMENTARY DATA

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.cveq.2015.12.011.

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