THE WINKS GREENE TRANSEVA'S POSITION IN THE MODERN WORLD AND ITS EFFECT ON THE EQUINE.

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Introduction

This research document was compiled in hopes of getting more accurate research on the Transeva available to the public. The first chapter will cover the physiology of the muscle. During this chapter different muscle types and fibres will be discussed as well as the role the muscle plays in the equine body. In chapter two the injured or stressed muscle will be the main focus. During this chapter subjects like, muscle fatigue and common sport injuries will be discussed in brief. There will also be a section on what happens to the muscle itself when it is injured. Furthermore chapter two will also be looking at the effect that injuries might have on the respected nerve of the injured muscle or muscle group. Following muscle injuries chapter three will include a brief discussion on some the current electro-therapies used by horse owners and trainers. These will include the H-wave, Transcutaneous Electric Nerve Stimulation (TENS), Electro- acupuncture, Ultrasound and Neuromuscular electrical stimulation (NMES). These discussions will include the effect of the machine as well as the injuries that can be treated by the various therapies. Furthermore each machine's pulse, current and frequency will be looked at. In chapter 4 the Transeva will be explained and there will be information on how the therapy works and when this therapy can be used in order to make the biggest change. This chapter will also focus on what makes the Transeva different from other therapies currently available on the market than other therapies. It will also contain information on how the Transeva compares to other electrical stimuli currently made available to the equine world. This research document will hopefully help clarify the reader on what the Transeva is and how it fits into the modern equine world.

Chapter 1: The physiology of the horse's muscle:

"Muscle tissue is responsible for the mechanical process of moving" (W, Freeman, OSU, Physical conditioning of horses) "Muscles are responsible for causing and controlling the movement of the joints."(The Dynamic Horse, Clayton, 2004). Muscles can either attach to bone directly or via a tendon. The muscle's origin & insertion (points of attachment) are usually onto two bones that form part of a joint, with the muscle placed in an area that allows it to have the most leverage on the joint. This helps to ensure that the least amount of energy will be required to allow for a large range of motion. (Understanding human anatomy & physiology, Longenbaker 7th edition) Muscles are generally classified according to the action they annunciate at a specific joint. All muscles regardless of their type can contract/ shorten. When the muscle contracts some part of the muscle body or the entire muscle body will move. (Understanding human anatomy & physiology, Longenbaker 7th edition) The muscle can either be an extensor or a flexor, an abductor or an adductor, an internal or an external rotator. Muscles can also be seen working in pairs with one muscle being an agonists muscle and it's opposing muscle, the antagonist muscle. (The Dynamic Horse, Clayton, 2004)The antagonist muscle will contract at the same time as the agonists muscle. The reason for this is to help stabilize the joint and prevent it from over flexing or extending. This action is called co-contraction (The Dynamic Horse, Clayton, 2004)

There are three types of muscles in the horse's body:

- Cardiac muscles,
- Smooth muscles and
- Skeletal muscles.

Cardiac muscles are specific muscles. The cardiac muscles or the muscles of the heart have the single function of contracting and relaxing the heart. These muscles cannot be consciously controlled but the nerves that supply the heart does have an effect on the rate and strength of each contraction. (Longenbaker, 7th edition) The contraction of these muscles is rhythmic and requires no stimulation from the nervous system to function properly. When the heart is beating the muscle fibres will relax completely after each contraction to prevent fatigue.

Smooth muscles are muscles that can be found in the walls of organs as well as blood vessels. (Longenbaker, 7th edition) These muscles play a role in digestion and circulation but same as the cardiac muscles these muscles are also voluntary muscles and the horse has little to no control over these muscles. (Higgins, Martin, 2011) the muscle fibres of a smooth muscle is narrow, tapered, rod- shaped cells that consist of only a single nucleus. The cells of smooth muscles are laid down in parallel lines and form the shape of a sheet. It is important to realize that although smooth muscles take longer to contract compared to skeletal muscles; this muscle group can sustain contractions for a longer period of time. (Longenbaker, 7th edition)

The third type of muscle is the skeletal muscles. The function of these muscles is to produce movement, stabilize joints and help maintain the horse's posture. These muscles are under conscious control by means of nerve impulses sent from the central nervous system, although these muscles can still move involuntary as a reflex response. (Higgins, Martin, 2011). These muscles are very elastic and can perform strong contractions. The function of this muscle group is to aid in supporting the body by helping to oppose the forces of gravity and in doing so, allowing the horse to stand upright. (Longenbaker, 7th edition). Another function of the skeletal muscle is to help maintain a consistent body temperature. This is done when the muscles break down ATP to enable movement, which result into heat being released and spread throughout the body. The skeletal muscles are also responsible for making the skeleton of the horse move, as well as other body parts e.g. the eye. (Longenbaker, 7th edition).

Skeletal muscles consist of skeletal muscle cells, also known as muscle fibre. Each skeletal muscle has a fleshy belly which is made up of thousands of intertwined muscle fibres and connective tissue called fascia. (W, Freeman, OSU) The muscle fibres decrease towards the origins and insertions of the muscle, and finally attaches to the relative bone via the tough fibrous periosteum. It can thus be said that muscles attach to the skeleton and therefore creates locomotion by passing over the joints. "Muscle tissue moves the body through a series of contractions and relaxations of muscle fibres" (W, Freeman, OSU, Physical conditioning of horses)

When looking at skeletal muscles in more detail, we can see that the muscles are made of muscle fibres that run parallel to each other. (Higgins, Martin, 2011) The fibres are bound together in bundles called fascicles with thin layers of connective tissue. The fibres are made up of myofibrils. These myofibrils enable the muscle to lengthen and shorten. (Higgins, Martin, 2011)

Another way to categorize the muscles in the horse is looking at the fibres in the horse's body. "The horse has three basic types of muscle fibres: Type 1, 2A and type 2B." (Energy and the performance horse, Pagan, Kentucky Equine Research, Inc.) These fibres are designed differently in both the way they contact and their metabolic function. Type 1 muscle fibre is designed for slow contractions and is also known as slow twitch fibres. Type 2A and 2B are fast contracting muscle also called fast twitch muscle fibres. Type 1 and 2B fibre types produce energy through an aerobic metabolism and thus require oxygen to function. (Pagan, Kentucky Equine Research, Inc.) This fibre produces energy slowly but the energy produced will allow the muscle to function properly for longer with little fatigue. Horses with a large amount of these fibres will take longer to fatigue and are perfect for endurance and eventing. (Pagan, Kentucky Equine Research, Inc.) Fast twitch muscles made up of 2B are physically larger muscles than slow twitch muscles and work an-aerobically. These muscles allow for powerful, explosive releases of energy but they tire out quickly. Horses with a majority fast twitch muscles generally make for good show jumping horses. (Pagan, Kentucky Equine Research, Inc.)

When looking at the energy in the horse's muscle it is important to notice what kind of movement the muscle was designed to do and how the body enables the muscle to function. When a horse moves it is crucial to remember the role of the aerobic and anaerobic metabolism and how it works. Both types are crucial when working a horse. Both types of metabolisms involve the transformation of Adenosine diphosphate (ADP) into Adenosine triphosphate (ATP). ATP is then broken down to create energy for movement to take place instead of the body having to create movement energy.

If a horse is conditioned properly for the work that is required of it, the body will have an increased amount of substances available in its body to provide what is needed for contraction

and relaxation of the muscle fibres. This will increase the horse's balance, coordination, strength as well as decrease their chances of injury and delay fatigue.

When the anaerobic metabolism is put into action, it enables the body to break down both carbohydrates and fat when oxygen and carbon dioxide is present. Because all of these substances are non-toxic and the body can remove carbon dioxide using haemoglobin, anaerobic metabolism is seen as a save metabolite function. If the horse's body is deprived of/ or lacking the oxygen that allows it to set this process into motion. (C.L. Stull, 1997)The energy that has been produced will enable the body to release ADP molecules to be transformed into ATP molecules, but with less efficiency. This process is called anaerobic metabolism. During this metabolism lactic acid is formed. (C.L. Stull, 1997)If the lactate is not removed from the muscle the muscle tissue can become acidic and in doing so reduce the body's ability to create ATP. If a muscle is toxic it will, with time, also have an effect on the muscle's ability to contract and thus the muscle will fatigue easily. (C.L. Stull, 1997)

When looking at these two metabolisms we can assume that the aerobic metabolism is used for long term creation of energy, while the anaerobic metabolism creates a short term solution. Both of these metabolisms depend on the circulatory system functioning optimally: anaerobic metabolism for the transport of oxygen and anaerobic metabolism for removing the lactic acid out of the muscle.

When muscles aren't able to function properly they will decrease in size. This is known as muscle atrophy. This can make the horse more prone to injury if the horse has to perform intense movement with a weak, atrophied muscle. (C.L. Stull, 1997)

When we're looking at the energy in muscles from a more scientific point of view we realize that muscles are the only tissue in the body that converts chemical energy into mechanical energy. The mechanical energy is then used to create tension in the muscle fibres. (LaSayo P.C, Woolf J.M, Lewek M.C, Reich T, Lindstedt S.L, 2003) A muscle can perform a variety of actions such as:

- concentric contraction,

- isometric contraction and
- eccentric contraction.

These actions are classified according to the change in the length of the muscle when tension is present.

When thinking of a muscle contraction most people will think of the shortening of the muscle but when the word “contraction” is used in physiology it refers to the activation of the areas in the muscle that generate force within the muscle fibres, also known as the cross bridges. In order to understand this fully one must understand how muscle contraction comes about. The process that takes place when muscle contraction is required is the sliding filament mechanism. When a force is generated within a skeletal muscle and the muscle shortens the thick and thin filament in each of the muscles sarcomere move, mast one another due to the activation of the cross bridges. During the shortening of the sarcomere there will be no change in the length of the thick or thin filament. This is known as the sliding filament mechanism of muscle contraction.

The Sliding filament mechanism is activated by an impulse send from the central nervous system, through a series of nerves that runs through the body known as the peripheral nerves. Thus we can see that muscle activity is controlled by nerves. . (Hammoudi, 2007)

The skeletal muscles are stimulated by the motor nerve unit of the somatic nervous system. A motor nerve unit is a bunch of motor neurons and all the muscle fibres they control. . (Hammoudi, 2007) The number of muscle fibres controlled by each unit may vary depending on the muscle e.g. muscles that are in control of the finer movements, like the eyes, have smaller motor units, whereas weight bearing muscles, like the gluteus, require a larger motor unit. The motor neuron connects to the muscle cells through their respected axons. . (Hammoudi, 2007) These axons branch of once they enter the muscle, and each of these muscles form a neuromuscular junction with a muscle fibre. Between each muscle fibre and axon ending, a synapse can be found. . (Hammoudi, 2007) Once the impulse is send down the nerve it will pass through the synapse with the help of a neurotransmitter and then into the muscle fibre itself. It

is important to realize that when one muscle fibre is activated a weaker response will follow throughout the rest of the muscle, because all the axons are connected to the same nerve. (Hammoudi, 2007)

Muscles have two types of contractions,

- isotonic and
- isometric contractions.

When a muscle is in isotonic contraction the length of the respected muscle will change, which will decrease or increase the angle of the joint, and in doing so, move the body. . (Hammoudi, 2007) Furthermore isotonic contractions can be categorized into two groups, concentric contractions (the muscle shortens) and eccentric contractions (the muscle lengthens). When a muscle undergoes isometric contraction the load/ tension will activate the muscle but the muscle will not change shape. (Hammoudi, 2007)

Chapter 2: A Stressed or injured muscle:

When speaking about an injured muscle we need to define what it is and how it occurs. Muscle injury/ muscle damage is very common in the modern horse and causes problems for both the horse and the rider. (Higgins, Martin, 2011) Muscle damage can occur due to ineffective, unbalanced, discomfort or restricted movement. It is important to remember that more than 60% of the body's weight is muscles. (Higgins, Martin, 2011)

2.1) Injured muscles:

Muscle injuries are mostly due to the following three factors: the muscle is lacking the strength or length required to work correctly, muscle fatigue and muscle lacking skill to perform required task. (S. J. Schilis, T.A. Turner, 2010) When looking at a muscle on a deeper level we can see that the fibres are torn when a muscle is put under too much stress. (Higgins, Martin, 2011) If fibres are torn excessively blood vessels can rapture which could cause internal bleeding, swelling or heat. If the necessary actions are not taken to aid in the healing of extensive muscle damage, this could lead to secondary muscle tension which will involve the body laying down scar tissue. (Higgins, Martin, 2011) If this occurs it would have a major effect on the elasticity and contractibility of the muscle. This will in turn cause a restriction in the movement of the muscle, which will prevent the muscle from performing optimally and cause more stress to be placed on the surrounding joints, tendons and ligaments. (Higgins, Martin, 2011) Another reason for the reduced amount of movement through the muscle could be because the nerve impulses that the brain sends to the muscle will make the muscle limit its movement in order to guard to protect the injured area. (Higgins, Martin, 2011) In muscle rehabilitation it has been found that skeletal muscles can change it composition and functional characteristics to adapt to certain amounts of stress. (Higgins, Martin, 2011) This ability can have both a positive and negative effect on a muscle during rehabilitation. If the horse is immobilized it could produce significant amounts of muscular change in a short time. (S. J. Schilis, T.A. Turner, 2010) Research also proved that mobilization should start s soon as possible after the injury occurred. This will allow for proper alignment of the regenerated muscle fibers. (S. J. Schilis, T.A. Turner, 2010) It will also help reduce the extent of connective tissue fibrosis, help increase flexibility of the repaired are as well as prevent further injury or reduce chances

of re-injury. (S. J. Schilis, T.A. Turner, 2010) by decreasing the movement and weight bearing activity in an injured muscle reduces the rate and quality of the recovery. (S. J. Schilis, *et al* 2010) Immobilization of an injured muscle could also lead to neural changes that affect the function of the muscle. (S. J. Schilis, *et al* 2010) Activating both the agonist and antagonist muscle with movement is crucial for optimum healing. (S. J. Schilis, *et al* 2010)

Muscle injuries can occur as a result of: trauma, micro trauma, overuse, pulling or straining a muscle, muscle atrophy, muscle fatigue and Delayed Onset Muscle Syndrome. (Higgins, Martin, 2011)

2.2) Muscle Fatigue:

"Fatigue is a state where the horse's ability to perform a specific type of work deteriorates because of the amount of work that has already been performed" (Vogel 2006) Another research article (Marlin, 2007) states that "Fatigue means mental or physical tiredness, usually caused by prolonged or intense activity, but also possibly caused by disease, lack of adequate nutrition or other anomalous factors." Muscle fatigue can be associated with tiredness in the muscle, but unlike tiredness, fatigue involves an element of pain which stops the muscle from contracting a releasing the way in naturally would. (Vogel 2006) Fatigue is a safety element the body naturally implements to ensure that severe exhaustion does not occur which will cause long term damage to the horse's muscles. Fatigue itself will only last for a short time period. (Vogel 2006)

When looking at a fatigued muscle we can see that one of the major elements of fatigue is the large amount of lactic acid and ammonia build up that can be found in the muscle fibres after hard exercise. (P.G. Gibbs, G.D. Potter, B.D. Nielsen, D.D Householder, W. Moyer, Texas A&M Uneversity) Muscle fatigue is most likely to occur in horse's who are asked to give powerful bursts of maximum effort which require all the muscle fibre to work. (Vogel 2006) This is because in lower levels of exercise the horse's body will switch the muscle fibre type ever so often to allow the fibres to rest before working again, in doing this the body prevents fatigue. The fibres used for short bursts high in power are much more sensitive to lactic acid build up due to their limited aerobic capabilities (Vogel 2006). Due to the large amount of stress placed

on the muscle the horse will require more ATP than its body can produce and this will force the muscle to produce energy an-aerobically. (Marlin, 2007) This will cause lactic acid to build up in larger amounts than the circulatory system can keep up with. This will cause an imbalance in the pH levels of the cell which will prevent the muscle from contracting properly. (Vogel 2006)

Muscle spasms and muscle cramps generally accompany an overworked or fatiguing muscle. Although these to terms may seem the same there is a difference between them:

A spasm is a sudden involuntary smooth or skeletal muscle twitch/ contraction, often accompanied by pain, which can range from very painful to mild ache. (Longenbaker, 7th edition) When a muscle is in the process of spasm it hardens and is hyper- reactive on palpation. When a muscle is in spasm its strength and agility is reduced and it cannot function optimally. (Longenbaker, 7th edition). If the spasm is left without the proper treatment the muscle can lose function of the muscle over time, it could cause discomfort and have a permanent effect on the horse's joints. (Porter 1998) Most spasms are not serious but uncomfortable. When a spasm occurs in multiple skeletal muscles it is known as a convulsion. (Longenbaker, 7th edition).

Cramps are strong painful spasms that generally last longer. Cramps normally occur after lengthy exercise.

2.3) Other muscle conditions:

2.3.1) Muscle pain:

According to Porter (1998) muscle pain is a form of physical stress. It is a way of draining both the physical and metal energy of the body. The body's natural defence against pain is to reduce the movement of the injured area to help guard the area. The energy used to keep this guard in place takes its toll on the body's physical energy. Furthermore it plays a big role on the body's emotional state. Because the brain is constantly reminded that the body is in pain it places a large amount of emotional stress on the body and I it prevents the body from focusing on performing optimally on all the other fields. (Porter, 1998)

2.3.2) Muscle weakness:

Muscle weakness is also a way of guarding an injured area. When a muscle injury/ stiffness is found in the body the brain will reduce that specific muscles range of motion in order to prevent further injury, but in doing so the muscle will weaken. If not treated the muscle fibres will continue weakening and muscle atrophy will set in. (Porter, 1998)

Chapter 3: Electro therapies and Ultrasound currently used for therapy on horses.

Electrotherapy is becoming very popular these days but although it may seem like a new modesty to hit the equine world, electrotherapy has in fact been around since the 1950's. It was during this time that people first started to recognize electrical currents in soft tissue. (Porter, 1998) After this further studies where put into place. This led to the use of these currents to stimulate tissue repair. (Porter, 1998) The use of electrical stimulation to aid in the improvement of muscle function can also be dated back to the 1950's. (Porter, 1998)

The general flow of an electrical stimulus used for therapy is shown in figure 1 below.

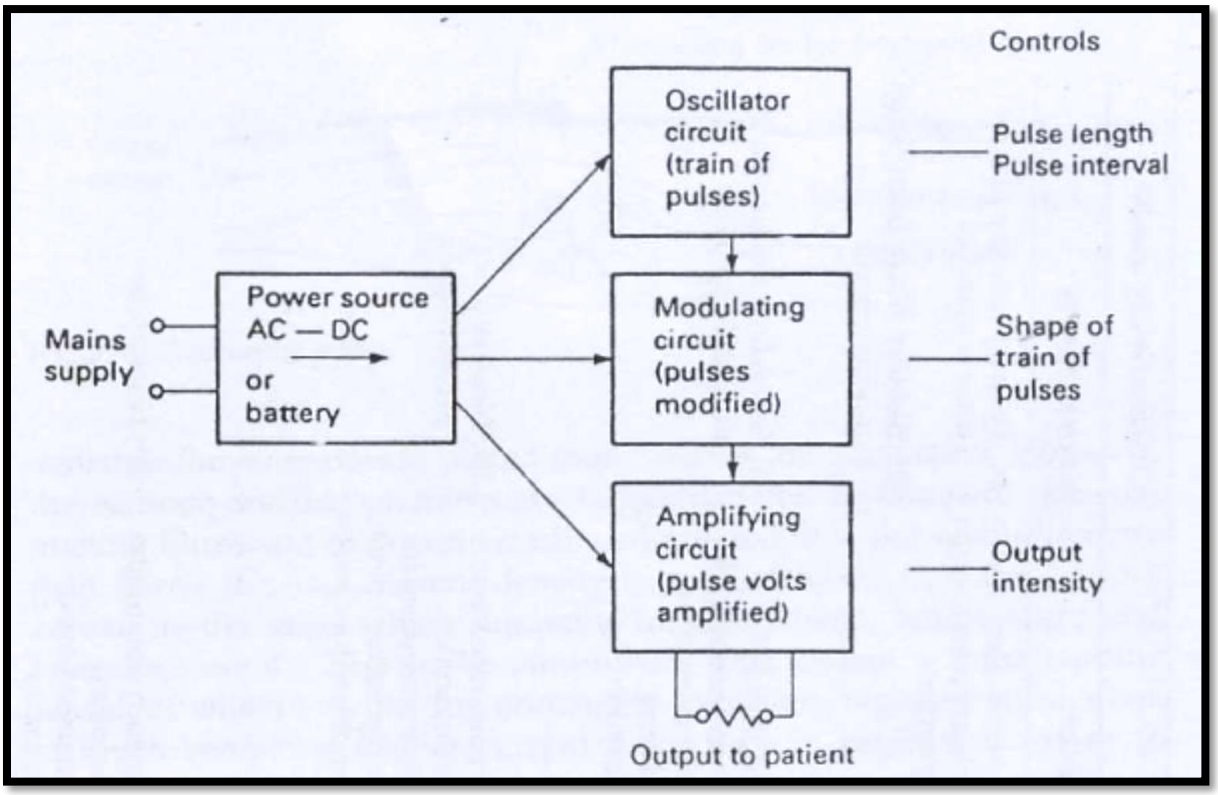

Figure 1: General flow of an electrical stimulus (Low, Reed, Dawson, 1994)

3.1) H-Wave:

The H-wave claims to be an electrotherapeutic machine which combines muscular and neurological stimulation. It consist of a two channel unit that is powered by a covered rechargeable battery that allows for easy transportation as it weighs in at only 3 kg. (Fresh Health machines & equipment, 2015). Figure 2 shows an example of the H-wave machine.

Figure 2: H-wave machine (premiermed.co.uk)

The H-wave was designed to improve the quality and reduce the healing time of soft tissue injuries. (Fresh Health machines and equipment, 2015) The H-wave is designed with a "bipolar exponential decaying waveform that enables it to penetrate deeper connective tissue with greater efficiency using a lower current" (Fresh Health machines and equipment, 2015). The waveform used by the H-wave replicates the natural nerve impulses also known as the Hoffmann reflex. Due to this, the body is more accepting to this kind of stimulation. According to the company that sells the H-wave this machine's signal has a "low tension, non-tantalizing and non-fatiguing qualities which is similar to the natural voluntary muscle contractions in the horse's body." (Fresh Health machines and equipment, 2015) One of the H-wave's main advantages is that it mainly affects the smooth muscles in the body without stimulating the motor nerve, according to research, though not credible. (Fresh Health machines and equipment, 2015)

The H-wave consists of an "intermittent wave" (Newmarket Equine Physiotherapy) where other electrotherapeutic machines make use of a square or diamond wave, these wave forms even at a standard intensity can be uncomfortable for the horse. (Newmarket Equine Physiotherapy) The waveform used by H-wave is said to be comfortable when applied and it has little dermal resistance and no appreciable muscle fatigue. (Newmarket Equine Physiotherapy)

More research needs to be done or made available before the true effect of the H- wave and the waveform current it produce can be fully understood.

The H-wave works on two different settings that can either be used separately or together. (Fresh Health machines and equipment, 2015)

The low Frequency has a current of 2Hz and is known as the therapeutic mode. This setting is used to create a “visible contraction, which increases the venous return of blood and stimulates lymphatic drainage through an injury site” (Fresh Health machines and equipment, 2015) Due to the increase of blood flow and lymphatic system the healing process is sped up. The H- wave helps relief pressure by removing the Toxins that congregate around the injured area and in doing so relief pain. (Newmarket Equine Physiotherapy)

The second setting of the H-wave is the high frequency setting. During this frequency 60Hz is being put into the body. (Fresh Health machines and equipment, 2015) The high frequency is used for pain relieve and can have a deep analgesic effect. This is accomplished by blocking the transmission of pain signals. It also encourages the release of the horse’s own natural pain reducing chemical known as endorphins. (Fresh Health machines and equipment, 2015)In acute pain some physiotherapists use the high frequency setting to reduce the pain before continuing with therapy on the lower frequency. (Fresh Health machines and equipment, 2015) The H-wave can be used by qualified physiotherapists and veterinary surgeons. The H-wave is FDA approved for muscle contraction but not for pain relief or healing of wounds according to the Medical Policy set up by Capital Blue (2015) The H- wave machine is a Class 2 a medical device and is CE certified complying with the Medical Devices Directive. (Fresh Health machines and equipment, 2015)

“The use of the H-wave stimulation is considered investigational for all indications, including but not limited to:

- Treatment of pain
- Wound healing
- Post operative treatment to improve function and/or range of motion

(Capital Blue, Medical policy, 2015)

The H-wave makes use of stick on electrodes (self- adhesive pads). These pads are placed close, or onto the injured area during an H-wave treatment. (Fresh Health machines and equipment, 2015)

According to Capital Blue, Medical Policy (2015), the two controlled trails undergone by the H-wave machine is not sufficient enough to make a conclusion about the effectiveness of the H-wave machine used for pain relief treatment. (Capital Blue, Medical policy, 2015) Additional studies especially blind studies need to be undertaken. No comparative studies has been done to evaluate the H-wave stimulus and whether or not it aids in wound healing, has been published to this date. (Capital Blue, Medical policy, 2015)

3.1.1) Case study: (MIE, Medical research)

Horse name: Tucker

Information: 10 year old advanced, eventer

History:

Fell in stables while tied up. Fell with legs open behind. And landed on right hind quarter. on and off lameness. Significant abduction of ne right hind leg mad him unstable to ride.

Treatment:

Required nerve blocking up to and including the hip joint. This produced a 70% improvement. Large amount of abduction wastage, increased psoas tone on Off hind as well as increased tone through the abductors. Hip received medical treatment as well as analgesic treatment which was provided with the Vet H- wave electrotherapy at the hip frequency of 60 Hz. Exercise program was devised. Manipulation under sedation was used to return the range of motion of the thoraco-lumbar spine

Results:

Having been too unsound to ride Tucker slowly returned to a normal gait. After 12 weeks in treatment was able to return to eventing training.

3.2) Transcutaneous Electric Nerve Stimulation:

During the 1970's people became more interested in electrotherapy. This led to the designing of a small battery operated device called the Transcutaneous Electric Nerve Stimulation (TENS). At first this device was mainly used to treat Carpal tunnel syndrome and chronic back discomfort. The TENS machine was specifically marketed for pain relief and releases a low frequency, smooth current. The first TENS machines to be created had very few adjustable pulse characteristics because it was made to be designed by the patient and not a specialist. Today the TENS is much more complicated and some units come with multiple pulse with and frequency options. (Porter, 1998)

The Transcutaneous Electric Nerve Stimulation (TENS) is another form of electrotherapy that has been used as a pain suppressor, and can also be used to assist with short term or long term pain relief. (Harding M, 2015) The TENS machine is a small battery-operated electrical unit. Electrode pads are connected to the machine and placed onto the body to deliver a small electric impulse to the surrounding nerve fibres. (Harding M, 2015) Pain relief is provided by blocking pain signals that is send to the brain via the spinal cord and peripheral nervous system. The TENS machine also stimulates the production and release of endorphins which is the animals natural pain relief hormone. (Harding M, 2015)The TENS unit stimulates the sensory nerves in order to relief pain. The amount of pain relief that the TENS machine provide will vary from person to person. (Oxford University Hospital, A guide to TENS, 2013)

The TENS machine is designed to work on 2 methods called Pain Gate Mechanism and the Andogenous Opioid System. The pain gating mechanism involves the activation of the sensory nerve fibres of the body and by doing this reducing the impulse send to the spinal cord. According to Tim Watson in his research work (2010) on the TENS, the fibres are best stimulated at a relatively high rate but he also states that it is difficult to find substantial research that states that there is a single frequency that works best for every patient. The high rate seems to cover the majority of people. (Watson T. 2010)

As an alternative to the high rate stimulating function the TENS also provides the option of a lower frequency setting. (Schils S.J, 2009) The lower setting is provided to stimulate the A Delta

fibres which are known to respond at a lower rate of stimulation according to Tim Watson (2010). In this setting the opioid mechanism will be activated. This will provide pain relief to the body by encouraging the body to release an endogenous opiate (encephalin) in the spinal cord which will reduce the activity in the sensory pathways. (Harding M, 2015)As with the pain gating principal there is also no set frequency that works optimally for all users. (Oxford University Hospital, A guide to TENS, 2013)

Furthermore the TENS allows for one last possibility for pain relief. If the user would like to stimulate both the above mentioned nerve types the TENS machine can be set on "burst mode stimulation". This is a higher frequency stimulation output (100Hz) which is interrupted at a rate of about 2-3 bursts per second. (Oxford University Hospital, A guide to TENS, 2013) This setting stimulates both the above mentioned methods of pain relief. When used on this setting it will deliver a pulse of a 100Hz rate which activates the pain gate mechanism but due to the rate of the burst, each burst will in turn activate the opioid mechanism. (Harding M, 2015) Although this setting seems to have the optimal effect on pain relieve many users have complained that this pulse is uncomfortable and they are less acceptable to this form of TENS because it has a grabbing or clawing sensation. (Harding M, 2015) This setting also causes more muscle twitching than the high or low frequency modes. A example of what the TENS pulse train during the burst mode setting, follows in Figure 3 below.

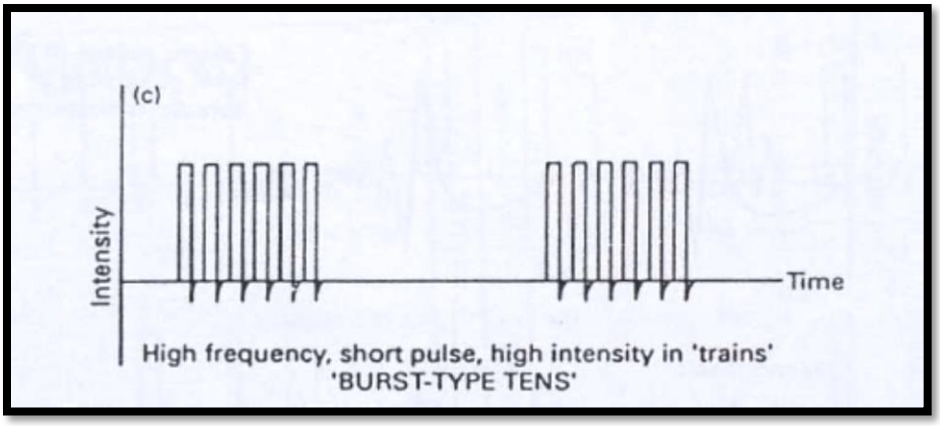

Figure 3: Sketches of TENS current (Low, Reed, Dyson, 1994)

It is important to realize that the pulse created by the TENS machine only penetrates a depth of 1-2 inches to stimulate the superficial nerves under the skin. (PhysioMed, A Practical Guide to TENS Therapy)

The TENS machine works in two ways:

1. High Frequency (90-140HZ)

   This is the most commonly used frequency and uses short duration pulses (100ms) though there is little research literature currently available to support the manipulation of the pulse width. The treatment is delivered at an intensity that can be felt without causing discomfort to the patient. (Watson T, 2010) The treatment time varies but 30min is the minimal time required to have an effect. (Watson T, 2010) Pain relief is instant but the carry over effect (how long the relief will last after the treatment) is limited. (Oxford University Hospital, A guide to TENS, 2013)

2. Low Frequency (2-5Hz)

   During this setting a longer pulse (200-250ms) with a lower frequency is used. The intensity that is used in this setting will need to be greater than the one used with the higher frequency.(Watson T, 2010) Again this settings minimal time required for efficiency is 30 minutes. During this treatment it takes time to build up the opioid levels required for effective pain relief. (Watson T, 2010) Once opioid build up is sufficient, the pain relief effect will last even after treatment until opioid levels return to normal. The time opioid levels will take to return to normal various from patient to patient. Figure 4 is an example of a convetional TENS pulse.

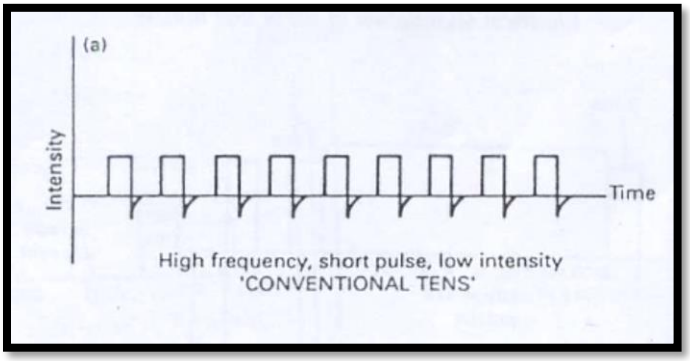

Figure 4: Sketch of TENS a conventional current (Low, et al. 1994)

The TENS can be operated by anybody but knowledge on where to place the electrodes are required for optimal effect. (A Practical Guide to TENS Therapy, PhysioMed) TENS can only function optimally once a diagnosis has been made as to why the horse is experiencing pain. The TENS is mostly used as an alternative to painkiller medication. (A Practical Guide to TENS Therapy, PhysioMed)

Symptoms of possible problems that can be treated by the TENS Machines:

- Arthritis
- Back and neck pain
- Bruising
- Rheumatism
- Sports injuries e.g. muscle strains etc

The TENS machine is ideal therapy to relief chronic pain. Unlike pain medication currently available on the market the TENS does not have any side effects like nausea or drowsiness. (A Practical Guide to TENS Therapy, PhysioMed) The TENS is also small (some the size of a cigarette packet) making it easy for the client to administer it at any time of the day. (A Practical Guide to TENS Therapy, PhysioMed) Due to the fact that the TENS pulse only penetrates up to 2 inches to the superficial nerves under the skin it does not pose any danger, although any injury require placing the electrodes on the head or neck needs to be considered carefully. (A Practical Guide to TENS Therapy, PhysioMed)

The TENS machine makes use of electrodes stuck to the skin which helps deliver the electrical impulse created by the TENS to the specific nerve fibres. “Usually the electrodes are placed around the pain area or on acupressure points.” (A Practical Guide to TENS Therapy, PhysioMed) Most of the research available state, that for optimal pain relief, electrodes must be placed as close as possible if not on the injured area. (A Practical Guide to TENS Therapy, PhysioMed) The TENS machine has some credible research available on how it can help with pain relief, but may need to allow more articles to be accessed freely by the public and possible clients. (Watson T, 2010)

Negative effects of the TENS:

- The TENS machine should not be used on patients with a demand-type cardiac pacemaker but is can be used with a fixed-rate pacemaker (Low, et.al. 1994)
- Electrodes should not be placed over skin lesions or open to wounds because of the different resistance and the risk of infection. (Low, et.al. 1994)

3.3) Electro-acupuncture:

Electro-acupuncture consists of two aspects. First, the acupuncture point may be found on the surface by testing the electrical resistance. Second, stimulation of the point may be given with an electric pulse rather than the traditional needle penetrating the skin. (Low *et.al*. 1994) Some electrical machines can test and stimulate the affected area using the same electrode while others can't.

Electro- acupuncture is done by inserting needles into the respected acupressure spots. An electrical stimulator will then be attached to these needles. A frequency of between 2-200 Hz is send into the muscle to help relief the pain (Shmalberg J, Huisheng Xie, 2011) Electro-acupuncture stimulation is used to stimulate the sensory nerve fibres and also makes use of the Pain Gating Mechanism. (Shmalberg J, *et.al* 2011) This is achieved by stimulating the nerve fibres which sends the pain impulse towards the brain.

Electro- acupuncture is being used more commonly because it delivers a stronger treatment than normal acupuncture. It is also more effective at regulating the endogenous opioid mechanism. This type of therapy is also easier to standardize which allows more accurate research to be done. (Sheta, Ragab, FArghali, EL- Sherif, 2015)

Electro-acupuncture can be used on two functions. A low frequency of 2 Hz, which is generally used to promote the release of endorphins. The 15Hz frequency seems to stimulate all opioids, which in turn affects all the receptors. (Sheta, Ragab, FArghali, EL- Sherif, 2015)

One of the electrical stimulators commonly used for electro-acupuncture is the TENS machine.

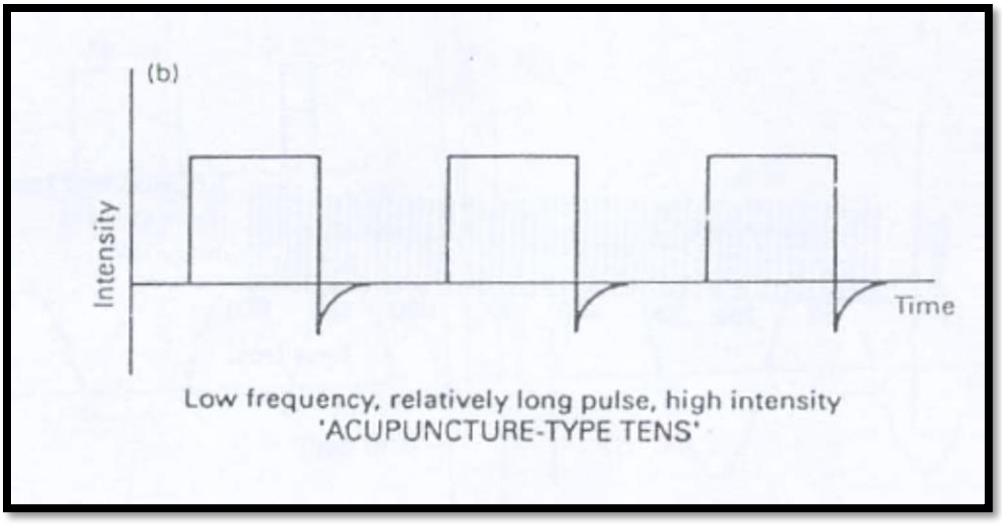

Figure 5: Sketch of an electro- acupuncture pulse when a TENS machine is used (Low *et al*. 1994)

The electrodes used during an electro- acupuncture treatment:

Traditional acupuncture makes use of thin needles which is placed at specific acupuncture points to release tension and increase circulation. These acupuncture needles can also be used during electo- acupuncture as electrodes when they are connected to an electrical stimulus (usually the TENS machine). The needle-type electrode has very little contact with the surface and its invasive an invasive type of electrode. Due to the fact that the needle penetrates the skin the stimulus has easier access to conductive elements e.g. blood, nerves etc. This also allows for the current to be more intense and specific. (Shmalberg J, *et.al* 2011) By inserting acupuncture needles into the body during treatment the needles may influence the release an activity of a potent neurotransmitter involved at the spinal cord. Higher levels of this neurotransmitter in the body have been reported after an acupuncture treatment. (Shmalberg J, *et.al* 2011)

Symptoms of possible problems that can be treated by electro acupuncture:

- Back pain
- Nerve injuries
- Analgesia

3.4) Ultrasound:

Ultrasound has many different uses in today's medical field such as diagnosis, measurement, scanning and treatment. It is important to realize that ultrasound along with laser therapy and magnetic field therapy, has an effect on the cellular level of the body (Renno, Toma, Feitosa, Fernandes, Bossini, Oliveira, Parizotto, Ribeiro, 2011)

According to Mary Bromiley (2007) in her book Equine injury, therapy and rehabilitation, ultrasound is an electronic device that sends out sound waves. Sound waves are pressure waves that can be sends through different mediums like air. Sound waves have specific frequencies and velocities.

"Therapeutic ultrasound is a comforting, mild heating, non- invasive modality used to promote tissue healing or before stretching tight or adhered structures." (Jennifer Brooks, 2011). During treatment the Ultrasound device sends a inaudible sound wave into the horse's body that are absorbed by the collagen- rich connective tissue in the body e.g. ligaments, tendons, fascia and scar tissue.

Ultrasound machines are battery operated or mains operated.

"Therapeutic ultrasound involves the conversion of electrical energy- via piezoelectric crystal mounted within the transducer head- into high frequency sound waves. Sound waves radiate energy by alternating between compressing and expanding material. "(Cameron, 1999) Research has shown that ultrasound can have either a thermal or a non thermal effect on the body tissue. (Brooks, 2011) More recent information (Renno et al. 2011) states that a biologically significant thermal effect can only happen successfully once the temperature of the tissue is raised between 40-45°C for at least 5min. Due to this reason ultrasound is inefficient at creating enough thermal charge in the muscle fibres to achieve this therapeutic effect when it is applied in clinical doses. (Renno et al. 2011)

When using the thermal setting, it allows the device to put a continuous sound wave into the body, which has the ability to increase heat in tissue with up to 5 degrees. This is an ideal

setting for pre-stretching preparation of tissue healing and to aid in decreasing inflammation. (Renno et al. 2011)

Non- thermal therapy is a pulsed setting that is ideal for promoting tissue healing and to aid in decreasing inflammation (Brooke, 2011). For proper transmission of sound waves, the owners are encouraged to shave the affected area to allow for optimal results. A gel is used to allow the waves to penetrate the skin instead of just reflecting back outwards. (Brooke, 2011)

One of the downfalls therapeutic ultrasound has is that it cannot penetrate the deep muscles effectively as it can only penetrate the body up to 5 cm. (Newmarket Equine Physiotherapists) This cannot be fixed by increasing the intensity of the treatment because in doing so the practitioner will damage the superficial tissue before reaching the deep tissue. “Therapeutic Ultrasound is usually applied at 0.75 MHz, 1MHz or 3MHz but the frequency used for the treatment depends on the depth of the targeted tissue.” (Michlovitz 1996, Cameron 1999, Mary Bromiley, 2007)

There are many injuries that can be successfully treated by therapeutic ultrasound for example, tendon or ligament injuries, muscle spasm/ tearing, joint effusion, open wounds and mild arthritis. Furthermore recent research has proven that therapeutic ultrasound can also have a positive effect on delayed bone healing according to a research article written by Corde (2010).

Therapeutic ultrasound can also benefit horses suffering from the following conditions:

- Increasing collagen elasticity of tendons, joint capsules and scar tissue.
- Increase motor and sensory nerve function, which helps to reduce pain
- Altering the contractive activity of the skeletal muscles of the horse and in doing so reduce muscle spasms
- Increase the blood flow which can help reduce healing time.(Brooks, 2007)

Treatment of bone within the first week after the injury has proven to minimize the cartilage production phase which allows for rapid ossification. It is important to note that “treatment in

the second stage of repair is contraindicated, ultrasound delaying bone union by stimulating an increased production of cartilage." (Pilla 1990, Bromiley 2007)

Although the therapeutic ultrasound device is a relatively save treatment modality care must be take when in use to avoid periosteal burns or tissue damage. Dangers that come with using this device may include an unacceptable temperature rise within the targeted area or a collapse of cells leading to deep tissue necrosis (Bromiley, 2000). Because equine patients can't tell an operator that the treatment is causing discomfort, it is important that a qualified person who can read the horses behaviour, note whether or not the horse is in pain. Mary Bromiley, a well known equine therapist, lecturer and author suggest that alternative rehabilitation therapies must be used with the Therapeutic Ultrasound as this treatment alone is far from satisfactory.

According to Bromiley (2007): "Incorrectly used, it is probably the most dangerous piece of machinery on sale to the general public."

3.5) NMES:

Neuromuscular electrical stimulation (NMES) unit was also developed in 1970 to aid in the building of muscles and to increase muscle strength. The NMES uses a biphasic wave (as shown in the figures on the right) with a direct current during the treatment. The device was designed so that two of the three electrode pairs deliver a sinusoid shaped wave of 250 ms on a specific time and 500ms off the time. The reason for this is because the 250 ms allows for a stronger muscle contraction but because the stimulus is applied for a larger amount of time it can increase the amount of sensation felt by the horse. (Porter, 1998) Because of this the output pulse gradually increases until it forms a peak before it drops away. (Porter, 1998) The ramping phase of the pulse allows for the output to be more comfortable and more tolerable for the horse. Due to the design of the pulse of the NMES the therapist can treat the deep muscles without discomfort (Porter, 1998)

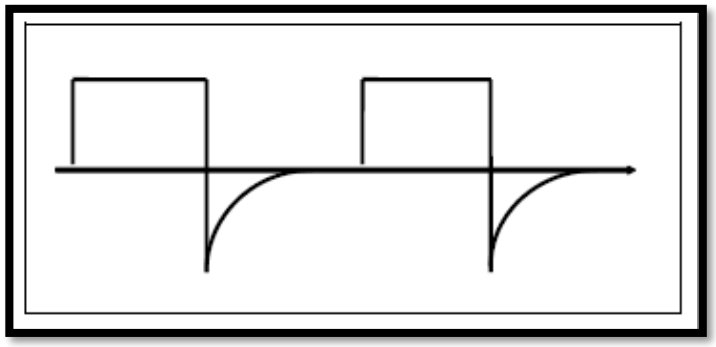

Figure 7: Asymetric biphasic waveform. (Watson 2013)

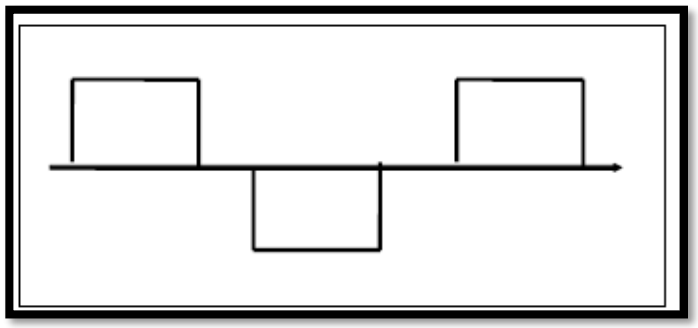

Figure 6: A symmetric biphasic waveform. (Watson 2013))

Neuromuscular electrical stimulation (NMES) devices are designed to transmit electrical impulses into specific muscle groups with the help of electrodes. The NMES stimulate the motor nerves, as well as the peripheral nerves which allow for a combined effect. (Geisinger Health Plan, 2015) The NMES allows for movement of the ligaments, tendons and muscles through a controlled muscular contraction. (Schils, 2009) Due the amount of movement of the various tissues can be controlled, the rehabilitation process can start sooner and even acute injuries can be treated. (Geisinger Health Plan, 2015)

The NMES is a form of both training the muscle and applying electrotherapy to the injured area (Smith, 2008). The NMES employs electrical impulses to create muscular contraction. (Geisinger Health Plan, 2015) NMES can be used to stimulate deeper tissue which allows for stronger muscular contraction. Stronger muscle contractions have proved to have an analgesic effect which lasts longer than other electrical stimulation (Schils, 2009). NMES has proven to be one of the most appropriate electrical devices to use on horses due to the controlled motor and sensory receptors of both the superficial and deep muscles, where the horse is still comfortable enough to comply with the treatment. (Schils, 2009) The NMES is often used to help with strength training in athletes as well as a post exercise recovery tool. (Smith, 2008)

The NMES is also used for rehabilitation purposes and has shown positive results in treating the following:

- Relaxing chronic or acute muscle spasms
- Enhancing blood circulation
- Re-educating muscles that has been injured
- Increasing range of motion
- Prevention of muscle atrophy
- Post surgery treatment
- Treating COPD

(Geisinger Health Plan, 2015)

The NMES uses pads as a form of electrodes that transverses the pulse into the horse's body.

NMES machines are available in many varieties. The NMES waveform can also be made available in multifunctional electro- therapeutic machines.

Chapter 4: The Transeva

4.1) The history of the Transeva:

The WG Transeva has come a long way since its original design. Although many think that electrotherapy is a modern way of treating and rehabilitating equine injuries, electrotherapy dates back to the early 1800's although electro- therapy was only used on animals for rehabilitation purposes in the early 1900's. (Appendix 1) The first person with a scientific basis on why it would be beneficial to put electricity into the muscle, was Morton Smart in his work, "The principles of treatment of muscles and joints by graduated muscular contractions" (Strong, 1967) published in the early 1900's. Dr Morton Smart together with Mr Rowley Bristow developed the original faradic apparatus, "Smart-Bristow Coil" It is with this apparatus that they started their research on the effect that electricity has on the muscle when applied in controlled amounts. (Strong, 1967)Charles Strong started showing interest in electro- therapy in 1914. (Strong, 1967) Over time he bought a "Smart-Bristow Coil" and started making some improvements to the device to make it more effective.(Strong, 1967) Strong strived to design a apparatus that produces a faradic current designed to penetrate the body while causing the least amount of discomfort. (Strong, 1973)

In 1939 Charles Strong extended his healing therapy to both horses and humans due a comment made by Lord Louis Mountbatten. (Strong, 1967) Although faradism was well known as a form of treatment/therapy it has not yet been used on horses. (Strong, 1967) Only once Strong started treating horses with the Strong Box did he realize that the electrical current was still too uncomfortable to be used on horses. (Strong, 1967)This was because; unlike humans horses cannot be persuaded that the uncomfortable feeling is going to improve them in the long run. With this in mind Sir Charles Strong designed the Strong Box. (Strong, 1967)

The new model was soon after, put to the test and did not disappoint. Although difficult to operate as it required two people it showed promising results. (Strong, 1967) From the experienced he gained when using this machine Strong set out to improve it even further and so in the 1980's the SEVA also known as the Transeva, shown in figure 8, was invented. (Strong,

1973) The reason for this name is because Trans means through and SEVA stands for Strong Electrical Veterinary Apparatus. (Strong, 1967)

The Transeva was much better accepted by even the most highly strung horses. The Transeva was easy to operate and required only one operator. It also gave the physiotherapist full control of the strength of each contraction as well as the speed of the contraction throughout the entire treatment. The Transeva was further improved by designing it to run on battery power.

Figure 8: : The Transeva. www.winksgreenetranseva.com/history.html

This not only made the Transeva easier to transport it also helped improve the safety of the machine. The Transeva's pulse in some way is designed the same way as a telephone, the pulse allows it to ring and seize when the current stops. Bearing that in mind the pulse of the Transeva is based on the same principal, to contract a muscle when the current is flowing and when the flow is cut off the muscle is allowed to relax and lengthen. (Strong, 1973) After several contractions to the stressed area, the operator as well as the patient can feel the muscle relaxing. This is because the muscle movement, stimulated by the Transeva, aids in increasing blood flow to the injured area as well as moving stagnant lymph away from the injured area.

The pulse is controlled by the operator who evaluates the tone of the muscle and adjusts the pulse accordingly. Due to the precise work of this machine the operator in now able to treat recent injuries with gentleness as well as treating old, hard injuries with more vigour to help recreate the movement, return elasticity and increase the range of motion. (Strong, 1973)

It is very important to realize that this kind of treatment is not a massage. "It is best described as a fully controlled form of artificial exercise which achieves in a fraction of time the results which massage and passive movements, no matter how skilfully applied (and all other forms of treatment known at the present time) aim to achieve, but rarely do." (Strong, 1973)

In 1988, Sir Charles Strong passed away and the Transeva was given to his disciple D.M (Winks) Greene who made it her life mission to improve and grow the Transeva that she has learned to love after spending 18 months learning how to use the apparatus from her mentor, Sir Charles Strong in 1952. In 1999 Winks Greene visited a technician, Nicoras who helped her add more movements into each pulse train created by the Transeva in the hopes of making the current more comfortable for horses. (Nicoras, 1999) She also added a screen to the previous Transeva to help make it more user friendly. She called the improved apparatus the Winks Greene Transeva. D.M. (Winks) Greene passed away June 2010. After her death the future of the Transeva was left in the capable hands of one of her students, Beth Shaw. Beth Shaw is currently based in South Africa, Karkloof where she continues to treat both equine and human patients with the WG Transeva. She also runs BSET Academy, an academy dedicated to training more therapists to use the WG Transeva effectively.

To see the full history of the Transeva, refer to Appendix A

4.2) What is the WG. Transeva:

The Winks Greene Transeva is an electrical apparatus used to stimulate the muscle to rhythmically contract and release. It was first used to aid in the healing of joint and muscle sprains and has since come a long way. It has since then come a long way and is used to treat multiple symptoms like:

1. Musculoskeletal injuries
2. Colic
3. Muscle atrophy
4. Stressed or hyper alert horses
5. Nerve pain
6. Stiff or sore horses
7. Tendon injuries
8. Lymphangites
9. Head shaking
10. Lactated tendons

11. Cold back
12. Aggressive behaviour
13. Training problems e.g. cantering straight, leaning on hand/s etc.

The symptoms conditions and problems mentioned above is not supported by relevant research but is based on cases seen/ found as well as treated and cured at BSET Academy or during practical field days with Beth Shaw (2015). More research needs to be done on the Transeva to substantiate this statement.

4.2.1) Process:

The steps followed when a Transeva treatment is given to horses:

1. The handler will enter the stable and gently place a head collar over the horse's head.
2. Salt water will then be applied to the horses back over the wither area, using a clean sponge, to help with conduction of the electricity.
3. A clean towel soaked in salt water will then be placed onto the horse's back and will be secured by a sursingle around the horse's trunk.
4. A negative plate will be placed between the wet towel and the surcingle.
5. The horse will now be walked away and towards the practitioner and the movement of the horse will be assessed.
6. The horse will now be led back into the stable and the practitioner will start by wetting the area he/she decided to start the treatment on. (Most treatments are started on the hindquarters)
7. The negative wire of the Transeva is now plugged into the Transeva as well as attached to the negative plate.
8. The positive hand piece is plugged into the Transeva.
9. Therapist must make sure that the intensity and the pulse of the Transeva is turned down to zero before placing the hand piece on the horse.

(B. Shaw, 2015, pers.comm.)

4.3) The Transeva under closer inspection:

4.3.1) Pulse- twin peak vs. A faradic current:

The twin peak waveform is a type of current that consists of instantaneous rises as well as exponential falls. These pulses function in pairs and lasts only 0.1 milliseconds with each peaks lasting only a few microseconds. The shape and duration of the twin peak pulse is usually fixed. The frequency of these pulse pairs can vary from 2-100 Hz. (Low and Reed, 1994). Due to the short peaks in the pulse high voltages are required to provide a high enough currency that is capable of stimulating the nerve fibres .A peak current of 2-2.5 Amps can be generated during a couple of microseconds but it is important to realise that the average current is low, 1.2-1.5 milliamps. (Low and Reed, 1994).

The faradic current is a short duration pulse. Electrical muscle stimulation is usually done with a faradic type of current. These are pulses of 0.1-1ms with a repetition rate of 30-100Hz. (Low and Reed, 1994). To make the treatment more precise, to a specific muscle or area, a small active electrode is used to apply the current to a motor point of the relevant muscle. The circuit is then completed with a larger electrode which is placed on a comfortable place on the body.

The pulse of a faradic current was originally powered by an induction coil and interrupter which was called a faradic coil, as described in Physical Principles Explained (Low and Reed, 1994). The pulse produced by this coil was unevenly shaped pulse. Figure 9 is a representation of what a faradic current would look like as well as what an unmodified faradic current looks like and how the current changes when it s put through the faradic induction coil. The nerves is stimulated by a peak in the voltage, after this spike the remaining part of the pulse operates at a much lower voltage and does not stimulate the nerve. Although the

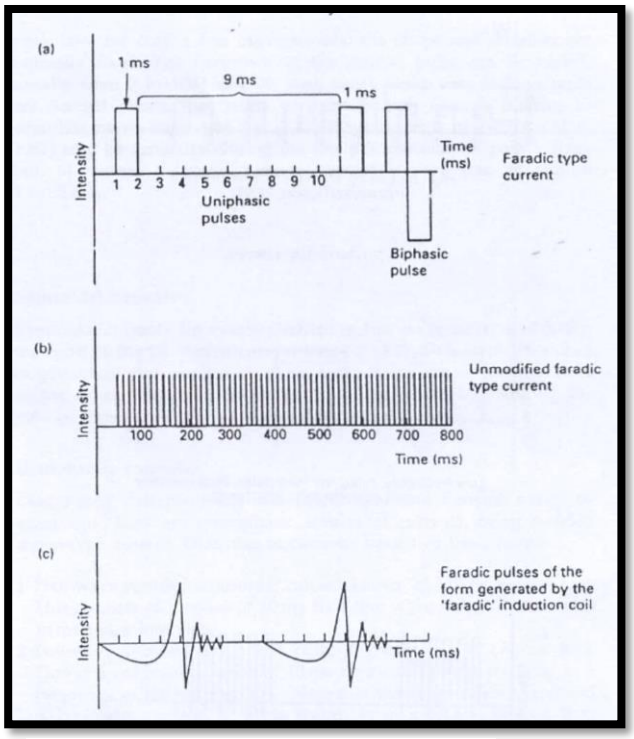

Figure 9: An example of a faradic current in different stages (Low et al. 1994)

alterations did not look the same in shape the where consistent in their total charge which ensured that no chemical changes occurred. The repetition rate was controlled by the mass and elastic properties of the mechanical interrupter which functioned at about 60 Hz. Faradic currents are a succession of these pulses which unmodified would produce a tetanic contraction. Treatment by faradic current or faradic type pulses is often called 'faradism'.

4.3.3) Currents

The current WG Transeva works as follow:

The W.G Transeva uses a unique electrical current which stimulate the muscles rhythmically. The Transeva operates with an Alternative current (AC) which means the voltage into the current changes and reverses because this type of current can change direction.

The average power consumption of the Transeva is 5 watts. The WG Transeva operates with a pulse duration of 0-255µs and a pulse rate of 0.5-2 seconds. The WG Transeva currently has a Voltage of 374 at its disposal. The Transeva Hertz is 200 cycles and the amperage sits at 0-59,93 milliamps.

The pulse train of the WG Transeva can be explained as 14 movements that create 7 twin peak actions. There is an average of 5 milliseconds between each movement.

It is surged to produce a near- normal tetanic-like contraction and relaxation of the muscle. Each muscle or muscle group can be stimulated with the Transeva via their motor nerves, producing a contraction with similar physiological effects to that of a voluntary contraction, peripheral nerves are also stimulated. It is best described as a fully controlled form of artificial exercise. The Transeva itself does not heal, but it creates the optimal environment for self healing and muscle building to take place.

4.4) Further development:

The Transeva has recently been brought under the microscope as more and more people became curious to how the Transeva works and what actually goes in to the muscle. In 2015 Beth Shaw actively started to do more research on the Transeva. The reason for her increased curiosity of the inner workings of the machine after many years of working with the Transeva

was due to the exposure. Beth Shaw is currently working towards creating an Equine WG Transeva. Although the Transeva has been used on horses for ages without causing any problems, Beth is becoming more aware of the need to cap the current Transeva's voltage. Although the Transeva has never harmed anyone as it is, some organizations and countries are finding it difficult to declare the Transeva safe to use on animals as well as people due to the large amount of power it possesses. (B. Shaw, 2015, pers. comm.) Beth Shaw, who also runs a Rehabilitation centre and Equine Transeva Academy, has decided it is with the best interests in mind that the Transeva needs to be capped. By capping the Transeva the overall safety of the machine will improve and any chances of hurting either human or animal will be minimized. (B. Shaw, 2015, pers. comm.) If the Transeva is capped and students travel overseas to further their technique any damage of the Transeva during travel will still have less chance of hurting anybody if damage to the Transeva has not been picked up. In doing this Beth hopes to get more people to accept and use the Transeva as well as getting more practitioners to practice internationally.

4.5) The effect that the negative plate has on the patient during and after treatment:

The effect of the negative plate on a patient is not yet fully understood and requires more research before a substantial answer can be given to this question. However when human patients are treated with the Transeva they mention feeling a current at both the positive (handheld) and negative (plate) electrodes of the Transeva apparatus.

4.6) What is the muscle like after treatment:

Every patient responds differently to the Transeva treatment. The muscle's response after the treatment will depend on the nature of the treatment i.e. whether the treatment was given to aid in healing of an injury or to activate nerves or reduce nerve damage. (B. Shaw, 2015, pers. comm.) The body will also respond differently when treatment was focused on aiding one of the body's systems (lymphatic system, digestive system) compared to how the muscles will react to a treatment applied to perfect the movement of an athlete's. Reducing adhesions and breaking down scar tissue. (B. Shaw, 2015, pers.comm.)

4.7) Why is the muscle stiff after treatment:

After some Transeva treatments human patients as well as the owners of the horses that received the treatment have reported signs of stiffness. This is a natural occurrence in some cases because the Transeva activated dormant muscles and, in doing so, the muscle will produce lactic acid. The reason for this is because the muscle has undergone long periods of time of inactivity. This is a necessary evil when a practitioner is working towards perfecting the movement of the patient. (B. Shaw, 2015, pers. comm.)It is important to remember that a Transeva treatment is not a massage but a fully controlled form of artificial exercise. (Strong, 1973) another reason why the muscle could be stiff after treatment is

4.8) The electrodes of the Transeva:

The Transeva has a positive and a negative electrode. The reason why the Transeva electrodes are unique is due to the movable hand piece (positive electrode). This allows the practitioner to be in full control of the apparatus as well as the current flowing through it into the horse. (B. Shaw, 2015, pers. comm.) The practitioner is trained to feel the tone of the muscle and can pinpoint, with the help of the Transeva, exactly where the muscle has a weakness, injury, build up scar tissue and adhesions in the muscles. By being able to hold the electrode the practitioner can feel the exact state of the muscle after each contraction. This prevents the muscle from being over worked and lends full control of the apparatus to the practitioner.

4.9) How does the Transeva Compare to the other Electro-therapeutic apparatuses:

Table on following page compares above mentioned and discussed electro- therapies. This table was set up to help compare the Transeva to some of the other modern therapies currently used in the equine world.

The Transeva Compared to other electrical devices:

	H- Wave	TENS Transcutaneous Electric Nerve Stimulation	Electro-Acupuncture	Ultrasound	NMES Neuromuscular electrical stimulation	Transeva
Current	Alternative current (Fresh Health machines and electronics)	Not currently available	Stimulus depended. TENS machine is normally used. Alternative current.	Sound waves	Direct Current	Alternative current
Waveform	Bipolar exponential decaying waveform (Fresh Health machines and electronics)	Asymmetrical rectangular biphasic pulse (PhysioMed) As well as a rectangular waveform (McGill, 2002)	Stimulus depended	The Sound waves are longitudinal waves consisting of areas of compression and rarefaction (www.physiopedia.com)	Biphasic waveform with a Sinusoid shape	Twin Peak waveform
Volts	10 V RMS (Max amplitude, Max frequency) (Fresh Health machines and electronics)	Max 110V on an open circuit (www.debmar.com) 0-50V(physiomed Series 3)	Depends on the stimulus	120- 240 V	0-110 V (open circuit) (Advanced Medical Supplies, www.advancedmedicalsupplies.com)	374 V
Amplitude	10 mA RMS output (Max amplitude, Max frequency) (Fresh Health machines and electronics)	All models start at zero amps but can go up to 50 to a 100 milliamps depending on model (McKean, 2006)	Depends on the stimulus	0-2.5W/cm² in continuous mode and 0-3W/cm² in pulsed mode (Transport user manual, 2009)	0-80mA peak in 500Ω load in each channel, constant channel. (Advanced Medical Supplies, www.advancedmedicalsupplies.com)	0- 59,93 milliamps.
Frequency	2- 60 Hz Output frequency. (Fresh Health machines and electronics)	The TENS also have different settings but for a normal method is at a rate of 90-130 Hz (Kenny, 2015)	3 Setting: 1. Low:2 Hz 2.Middle: 100 Hz 3. High: 200 Hz	3 settings: 1. 0.75 MHz 2. 1 MHz 3. 3MHz 1 Hz is one cycle in a second	1Hz- 160Hz depending on the model	200Hz
Channels	2 channels (MIE medical research uk.)	Dual, isolation between channels. Can have one or 2 channels allowing for 1 or two pairs of electrodes. (McKean, 2006)	Depends on the stimulus	Not applicable	Dual, isolated between channels	
Electrodes	Self Adhesive re-useable electrodes. Requires 1 electrode per muscle belly that requires stimulation. An electro-conductive solution aids in conduct current	Self adhesive, re- usable electrode pads	Electro-acupuncture uses acupuncture needles as electrodes. The needles are then connected to a electrical stimulus	Ultrasound gel is used so that pulse wave can enter body	2-3 pairs of Self Adhesive pads is used as electrodes in an NMES treatment	Consist of a moveable hand piece (positive) and a plate (negative). Salt water is used to conduct the current.
Power Source	Battery operated (Fresh Health machines and electronics)	Battery operated	Depending on the electrical stimulus. TENS: Battery operated	Battery operated	Battery Operated	Battery operated
Duration of treatment		Min length of a treatment is 45 min but can be used for up to 12 hours (Kenny, 2015)	30 min (The Horse, 2007)	10-20 min (Health Equine Therapies 2015)	5-20 min per treatment which is applied directly to the lesion (Porter)	A treatment lasts 45min -1hour and can be administered every second day or 3 times a week depending on injury

4.9) Case Studies and testimonials:

Although research on the Transeva is lacking some case studies and testimonials can provide some evidence that the Transeva does in fact have an effect on the healing and treating of injuries as well as aiding in perfecting the movements of athletes be it humans or horses.

4.9.1) Charles Strong's Case studies:

A) **Horse name:** 4year old Stallion

History: Kicked on the stifle by a brood mare. The stallion developed a large haematoma enveloping the patella and other surrounding structures. Considerable heat and it was tenderness to palpation and could hardly place any weight on the leg. The stud feared that the stallion could miss the his first season at stud

Treatment: Charles Strong treated the stallion with rhythmical muscle contractions which produced complete relief of all the symptoms.

Result: The stallion did not miss a single mare during his season.

B) **Horse name:** 3 year old Thoroughbred (Flat) racehorse

History: Impossible to train due to the fact that he was tracking inwards with his right hind leg to such an extent that he was brushing his left hind hoof and fetlock. The racehorse was also striking into the flexor tendon of near fore (left front) with the toe of the off hind (right hind leg). Due to this the trainer had to keep the near fore leg heavily padded to protect the tendon from injury.

Treatment: During the treatment he received from Charles Strong it was noted that racehorse had a strain to his adductor muscles of his offhand (Right hind leg) thigh. The main muscles he suggested that is put under strain was the Adductor Femoris, Sartorius and, Illiopsoas.

Result: After 3 weeks of treatment the racehorse returned to training without needing any protection of the near fore (left front leg) and over time turned into a winner.

5.9.2) Winks Greene's Case studies:

A) **Date and place:** Scotts Brothers 1/7/2006

Horse name: Mad Max

History: Uneven swelling along a scar from a colic operation.

Treatment: Needed to be sedated for the treatment. Treated around and on the affected area to help increase the circulation. Took Rx very well.

Result: Showed a decrease in swelling

B) **These are only notes on Gondoliers multiple visits to The Natal Rehabilitation Centre as well as some information about the treatments leading up to the Rothmans Durban July.**

Raced from 3-7 years 1982-87 won 8 races 1600m- 2200m July handicap.info

Gondolier was

C) **Date and place:** 15/04/92

Horse name: Inccinclecent Star

History: Fell in full gallop with O/H extended back and N/H extended forwards. Badly ricking/ injuring the pelvis as well as the SI joint of the N/H. Dragging N/H toe as well as a reduced range of motion

Treatment: Treatment to the N/H shows nerve involvement over the sciatic nerve. Was very sensitive over the sub luxed area.

Result: Remarkable improvement after treatment

Conclusion:

In conclusion to this document more information on the Transeva was made available and in doing so more accurate knowledgeable decisions can hopefully be made when deciding which therapy to use on an equine athlete. Knowledge on the physiology of the muscle and what occurs to the muscle when it is injured was also covered. Information on the effect that an injured muscle may have on the nervous system was also mentioned in this document Furthermore information on what to do to aid in the healing of an injured muscle was discussed as well as which electro-therapies are currently used in the equine world and what they are mostly used for. The Transeva, what it does, how it works and its place in the equine world was discussed as well as how it compares to current therapies

There will also be a section on what happens to the muscle itself when it is injured. Furthermore chapter two will also be looking at the effect that injuries might have on the respected nerve of the injured muscle or muscle group. Following muscle injuries chapter three will include a brief discussion on some the current electro-therapies used by horse owners and trainers. These will include the H-wave, Transcutaneous Electric Nerve Stimulation (TENS), Electro- acupuncture, Ultrasound and Neuromuscular electrical stimulation (NMES). These discussions will include the effect of the machine as well as the injuries that can be treated by the various therapies. Furthermore each machine's pulse, current and frequency will be looked at. In chapter 4 the Transeva will be explained and there will be information on how the therapy works and when this therapy can be used in order to make the biggest change. This chapter will also focus on what makes the Transeva different from other therapies currently available on the market than other therapies. It will also contain information on how the Transeva compares to other electrical stimuli currently made available to the equine world. This research document will hopefully help clarify the reader on what the Transeva is and how it fits into the modern equine world.

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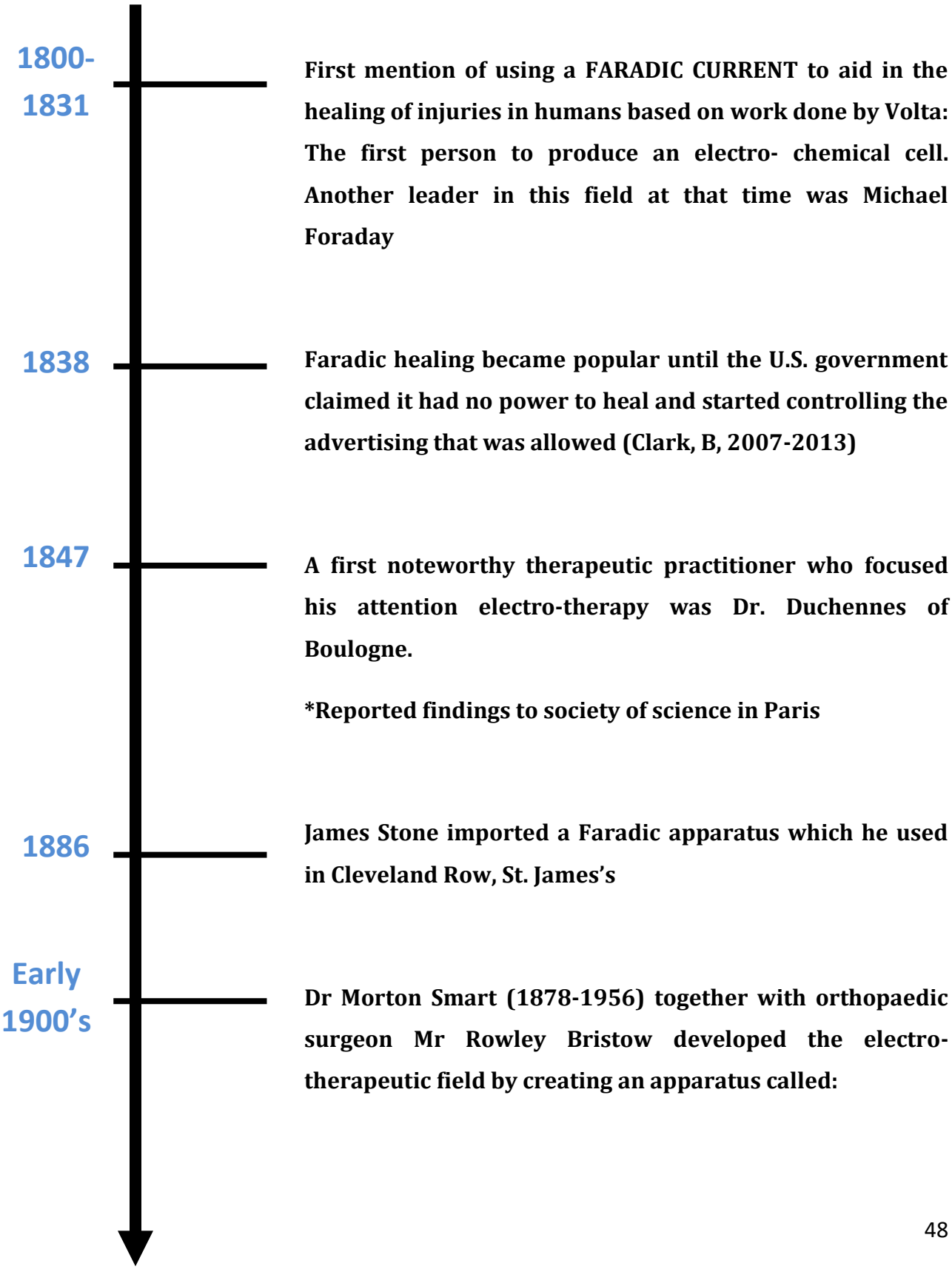
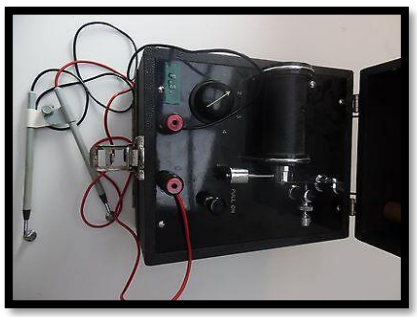
Appendix A:


1800-1831
First mention of using a FARADIC CURRENT to aid in the healing of injuries in humans based on work done by Volta: The first person to produce an electro- chemical cell. Another leader in this field at that time was Michael Foraday
1838
Faradic healing became popular until the U.S. government claimed it had no power to heal and started controlling the advertising that was allowed (Clark, B, 2007-2013)
1847
A first noteworthy therapeutic practitioner who focused his attention electro-therapy was Dr. Duchennes of Boulogne.
*Reported findings to society of science in Paris
1886
James Stone imported a Faradic apparatus which he used in Cleveland Row, St. James's
Early 1900's
Dr Morton Smart (1878-1956) together with orthopaedic surgeon Mr Rowley Bristow developed the electro-therapeutic field by creating an apparatus called:

Early 1900's

"Smart-Bristow Coil"

The " Smart- Bristow Coil was improved during the first world war to make the current less painful and the treatment more precise" (Glendale Hospital Museum, 2015)



1912

Morton Smart published account of treatments done with Gradual Muscular Contractions. Morton was knighted for his work.

1917

Orthopaedic surgeon Walter Rowley Bristow (1882- 1947) First description of pain free method of electrical nerve stimulation: His book "The treatment of joint and muscle injuries." (Glendale Hospital Museum, 2015)

1930

Charles Strong qualified as a chartered physiotherapist. Strong was, soon after employed in 2 big hospitals in the Orthopaedic department. During this time Charles Strong became acquainted with the different forms of electro-therapy available as well as the "Smart-Bristow Coil". At

this stage electro-therapy was only used for the rehabilitation of atrophied muscles.

1932

During a personal treatment given by Charles Strong to Lord Louis Mountbatten after a polo injury he learned about Morton Smart: Dr Smart used the faradic current for immediate treatment of muscle sprains to increase healing time and restore muscle function.

Note: Morton Smart also used his apparatus to treat polo players' injuries.

1933

Morton Smart followed up on his report made in 1912 with his book "The principles of treatment of muscles and joints by graduate muscle contractions"

* Sparks Charles Strong's interests

1934

Charles Strong adopts Morton Smart's technique and bought his apparatus. Even though Strong was getting good results from the "Smart-Bristow Coil" he still believed the apparatus could be improved and he set out to do it. Over time he developed a more acceptable current.

1934

Charles Strong treated Lord Mountbatten with his new version of the machine and Lord Mountbatten asked: "As

humans respond so rapidly to this form of treatment for their injuries why isn't it used on horses for theirs."

 # Charles went on to treat two of Lord Mountbatten's polo ponies that even veterinarians struggled to get sound. Within a fortnight both ponies where sound.

Lord Mountbatten suggested that Strong visit both Dr Morton Smart & Percy Stone (Remaining son of James Stone – Original Importer, 1886)

 # Morton Smart agreed that Charles Strong can take over his practice after World War 2

1934-1939

Strong realised that while his current machine is achieving good results in the equine world the current is still not well tolerated by the horses.

Developed a new machine for both human and equine use but before it could be tested the war broke out and the model was lost.

1939-1946

WORLD WAR TWO

Small improvements and developments took place during the war to help make the make the apparatus more comfortable for horses.

1946

Improved apparatus was redesigned after the war and put to the test. It was still too difficult to use as it needed 2 operators and current was still uncomfortable.

With the new knowledge gained from the tests done with this apparatus further improvements could be made.

1950

Charles Strong created the "Strong Box"

Figure 10 : Sir Charles Strong treating a horses shoulderwww.winksgreenetranseva.com/history.html

1952

D.M Greene (Winks) travelled to England and apprenticed with Sir Charles Strong. During the next 18 months Charles Strong taught Winks how to treat musculoskeletal injuries with the Strong Box on both horses and humans. She too started on polo ponies.

1953

Figure 11: The Strong Box www.winksgreenetranseva.com/history.html

Winks Greene returned to South Africa with a Strong Box. Apon returning she was called out to treat a racehorse called Royal Warrant who ended up winning the Johannesburg Summer Handicap. This was her first horse she treated successfully in South Africa. (Personality, 1994)

1974

Charles Love Strong becomes the first physiotherapist to be awarded knighthood for treating Lord Mountbatten's polo ponies.

1980

The first <u>TRANSEVA</u> was created.

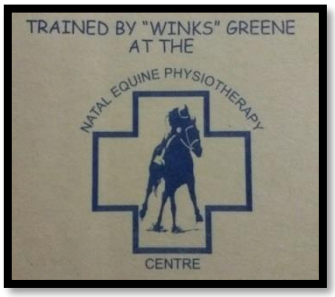
Trans: Through, S- Strong, E- Electrical,

V- Veterinary, A- Apparatus

Figure 12: The Transeva. www.winksgreenetranseva.com/history.html

1974

Winks Greene divorced and the next 10 years of her life consisted of working on her own farm, The Wolds, with Sussex cattle, pigs as well as a few horses



1984

Winks Greene opens her own rehabilitation centre in Kwa-Zulu Natal, South Africa called: Natal Equine Physiotherapy centre.

1953

1984

This was also the year Winks Green had a big break through when she used the Transeva to rehabilitate a racehorse called Gondolier who was expected to never race again after a hind quarter injury.

1985

After 3months of treatment by Winks, Gondolier went on and won the 1985 Rothmans Durban July Handicap. Durban July

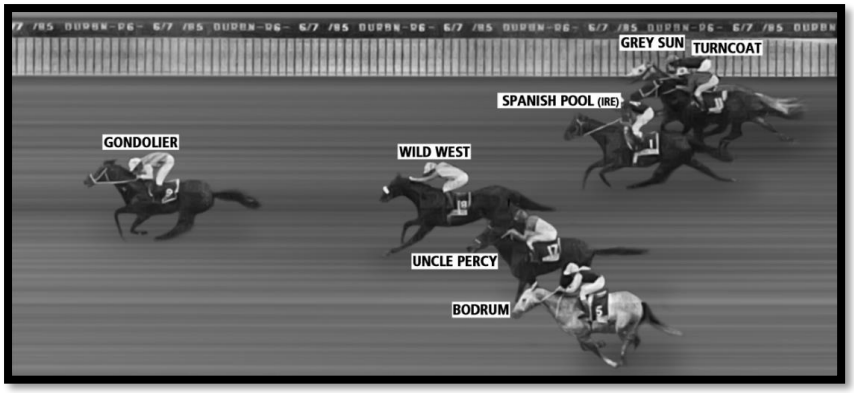


Figure 13: Can be found at: http://julyhandicap.info/index.php?page=racedetail&raceheadid=349

Late 1980'

After Gondolier Winks has made a name for herself. Winks contributed to various magazines and journals, including SA Racehorse and Parade. One of the founder members of the ACPAT (Association of Chartered Physiotherapists in Animal Therapy) under the auspices of the Royal College of Veterinary Surgeons, she is the only founder member outside the United Kingdom. Winks was an honorary helper of CROW.

1988

Sir Charles Love Strong passed away at the age of 78. Strong left all his work to his student Winks Greene.

1988-2010

Throughout Wink's life she devoted her time to rehabilitating racehorses, other animals and athletes. She also trained many students in the art of rehabilitating animals

1988-2010

Winks Greene continued to alter and improve the current to make it more comfortable for the patients be it equine or human. She later renamed the apparatus the Winks Greene Transeva as it is still known as today.

Figure 14: Winks Greene in her element. Found at:

2008

BSET Academy and Natal Equine Rehabilitation Centre re-opens at Manyatta Farm in Karkloof.

2009

Winks Greene handed the Equine division of the W.G Transeva work over to Beth Shaw. Winks Greene left the Transeva Company to her daughter Felicity Whitton.

2010

D.M. "Winks" Green passed away.

2015

ETT was founded by Beth Shaw

2015

ETT- AAP was founded by Beth Shaw