An initial investigation into the effects of The Equine Transeva Technique (pulsating current electrotherapy) on the equine *Gluteus superficialis*

Knaggs, H. [1], Tabor, G. [1] and Williams, J.M. [1]

[1]Hartpury University, Gloucester, United Kingdom, GL19 3BE

Corresponding Author: Hannah Knaggs (knaggs.hannah@gmail.com)

Abstract

The Equine Transeva Technique (ETT), is a novel electrotherapy, which utilises pulsating current electrotherapy to target sensory and motor neurons. The technique may facilitate increased circulation and correction of musculoskeletal issues and injuries, such as tendon and ligament tears and muscle atrophy. Despite the importance of understanding the impact of ETT on horses, no current scientific research exists in this area. This preliminary study investigated the effects of ETT on the musculoskeletal system of the horse, specifically within the *Gluteus superficialis (GS)*. Using surface electromyography, muscle workload was measured in 11 sound and healthy horses of varying breeds and disciplines within the inclusion criteria. Integrated electromyography (iEMG) calculated the percentage change in maximal contractions before and after ETT treatment during one minute trials at 30 second intervals. An ANCOVA determined if these constituted significant changes (Bonferroni adjusted alpha: $P \leq 0.02$). Significant differences in muscle workload were found on the left side between pre and post treatment readings across trials ($P \leq 0.02$), however no significant changes occurred for the right side. The majority of horses (82%; n=9) experienced bilateral changes, with 78% of these (n=7) exhibiting a negative change in muscle worload recorded from the pre treatment condition, which may indicate muscular relaxation. The results suggest ETT may have some effect on muscle workload in the athletic horse, however further research is needed to confirm the effects observed. Future studies should include randomising the side which is treated first, a larger sample size, expansion of temporal variables and consideration of a longitudinal study to determine if these trends accrue over multiple maintenance-purposed treatments.

Keywords: Electromyography, Equine Therapy, Equestrian Sport, Neuromuscular Physiology

No conflicts of interest apply to this work.

Introduction

The Equine Transeva Technique (ETT) is a method of electrotherapy utilising a high voltage current which is used to treat various musculoskeletal issues and injuries, such as muscle atrophy and pathology within the tendons and ligaments in humans (Arnold, 2016). This technique was first used in horses in the 1980s and is becoming more widespread as an adjunct treatment to maintain the current level of performance in the equine athlete, however this is not evidenced in scientific literature; despite the use of ETT within equestrianism, limited studies have investigated the short and long-term impact of the technique. The ETT machine produces twin peak monophasic waveforms that are reported to stimulate the sensory and motor neurons within soft tissue structures and in turn facilitate increased circulation (Arnold, 2016). The modality is thought to allow a higher voltage to be used compared to models such as Transcutaneous Electrical Nerve Simulation (TENS), which is believed to produce a more forceful current, however this is also currently unfounded due to the lack of research into ETT. Cyclic contraction and rest periods target sensory and motor neurons, communicating with the brain and spinal cord, to react via the motor circuits, which are responsible for locomotion (Kanning et al., 2010; Sandoval et al., 2010).

An ETT treatment consists of an electrical impulse emitted by ETT through the positively charged hand piece, creating rhythmic muscular contractions with the aim of normalising muscular tone. The use of ETT in a rehabilitation programme is similar to other electrotherapy methods in that the treatment is concentrated around the identified lesion or injury (Tabor et al., 2020). When muscle deteriorates, or wastage occurs such as that seen in muscle pathologies (Tabor and Williams, 2018) it is commonly associated with a decreased cross-sectional area (Kouw et al., 2019; Mukund and Subramaniam, 2020) and in humans, this has been correlated with pain (Hides et al., 1996). The presence of pain can alter movement patterns and induce loss of performance (Scheven, 2010). While electrotherapy can be useful in such cases, the presence of pain should always be evaluated by a veterinarian prior to treatment to identify indications or contraindications present (Adair and Phillips, 2018).

Evidence surrounding therapies for equine musculoskeletal conditions, including altered muscular function and muscle atrophy is limited, however translation of research that has been conducted on human subjects can assist clinical reasoning when selecting appropriate interventions for treatment in horses (Tabor, 2018). Current knowledge of ETT is sparse, with little known about the precise mechanics of ETT or how the technique impacts muscle physiology. Previous case studies on South African racehorses have reported that ETT is successful in treating soft tissue injuries, including muscle, tendon and ligament lesions (Arnold, 2016). Because this has not been objectively validated, there is a need for investigation surrounding how this therapeutic method impacts the musculoskeletal structures. With the spread of the technique and its arrival into the equine electrotherapy market, this investigation focused on identifying what effect, if any, the technique has on one of the main hindlimb locomotor muscles responsible for power generation and contractile force (Leisson, Jaakma and Seene, 2008).

This study aimed to evaluate if ETT increases motor neuron activity in the horse and determine the duration of any effects observed, using integrated electromyography (iEMG). We hypothesised that the muscular workload would vary substantially between horses, but that changes would occur between pre and post treatment trials.

Methods

Ethical approval for the study was granted by the Hartpury Ethics Committee.

Subject Criteria

Data were collected from 11 horses (mean age: 10.8 ± 3.1 years, mean height: 164.4 ± 4.1cm, sex: 6 mares, 5 geldings, of various breed). Horses included met strict inclusion and exclusion criteria in order to increase the validity and reliability of results within subjects (Table 1) (Nankervis et al., 2015). This allowed increased accuracy in comparison of horses due to similar fitness levels and body composition (Huber et al., 2011). The horses had no clinical signs of pain and consent for participation was gained as required by the UK Veterinary Surgeons Act (Exemptions) Order 2015. Horses were previously habituated to the ETT technique having undergone a minimum of one ETT treatment in the last 12 months, but not within the six weeks prior to this study (Petropoulos et al., 2014).

Table 1: Inclusion and exclusion criteria for participants

Inclusion	Exclusion
Minimum of 1 ETT treatment in the last 12 months, but not within the 6 weeks prior to the study	Pain or lameness
Sound/Pain free	Significant muscular atrophy in hindquarters
152.4-182.9cm in height	No exposure to ETT in last 12 months
Mare or Gelding	Any previous neurological diagnoses
7-20 years of age (ideal 10-15)	Not in regular exercise (less than 3 sessions per week)
In regular exercise (minimum 3x/week)	Less than 152.4cm or over 182.9cm in height
	Less than 7 years of age or over 20 years of age

Subject Preparation

Horses were restrained with a halter and either placed into secure cross ties or tied in an enclosed stable depending on which method was used in the horse's normal environment (Jonckheer-Sheehy and Houpt, 2015) (Myers, 2005). The horse was required to be standing square, with a neutral head and neck position (Alvarez et al., 2006). In order to prevent factors that may influence muscle movement, stimuli around the horse i.e. distracting sounds and peers were removed as much as possible (von Borstel et al., 2010). The practitioner stood at the caudal end of the horse and the researcher stood at the cranial end of the horse during data collection trials to monitor any movement that might compromise the data. A single researcher placed one surface electromyography sensor (sEMG), to minimise variance of placement, using the *tuber coxae*, *tuber sacrale* and *tuber ischii* as bony landmarks to locate the belly of the left and right GS (Williams et al., 2013). A chalk outline of the muscle was then drawn based on anatomical landmarks in relation to the belly of the muscle to ensure correct placement (Zaneb et al., 2009). The determined sensor location was shaved to 0 mm hair length using a disposable razor, and a 70% isopropyl alcohol skin wash was applied with a cotton pad to the shaved area and allowed to evaporate before attaching the sensors (De Luca et al., 2010; Williams, 2018). The sensor was aligned with the muscle fibre direction, positioning the arrow towards the hock (Zsoldos et al., 2018) and secured using the system's own adhesive backing. All sEMG data collection and analysis were conducted in line with Surface Electromyography for the Non-Invasive Assessment of Muscles (SENIAM) guidelines (SENIAM, 2020).

Data Collection Trials

Data were collected using one sensor on each GS from the Delsys, Trigno™ sEMG system (Boston, MA, USA). An initial bilateral sEMG reading, lasting 60 seconds, was recorded to ascertain each horse's pre treatment muscle activity allowing data to be normalised to the maximum contraction (Hanon et al., 2005). This was repeated with a 30 second break in between each trial to gain a total of three 60 second trials and if the horse moved prior to the 60 second mark, the timer was restarted in order to form the true static baseline. The horse then underwent a 15-minute ETT treatment on the left hindquarter with the sensors remaining *in situ* for the duration of the treatment to achieve a prompt recording immediately following treatment (Figure 1). The practitioner moved the hand piece, which served as the electrode, over the area. As per the ETT equipment requirements, and completion of an electrical circuit and thus conductivity, was established via a second electrode at the withers (a metal plate underneath a by a saline soaked towel). A saline wash was applied to the area of treatment (GS) however this was avoided in the region of the sEMG sensor. A trial recording was then taken from the left sensor immediately after the treatment, giving the therapist a 15 second countdown to remove the machine and immediately begin the sEMG recording (Williams et al., 2013). Two additional left side trials were conducted with 30 second intervals between 60 second recordings. An identical process was then conducted on the right *GS* including treatment and data collection trials.

Figure 1: Experiment set up during treatment between pre-treatment and post-treatment trials. In this image, the therapist is treating the hindquarter with the handheld device which is connected to the metal plate on the wither; the sEMG sensor can be seen above the practitioner's hand.

Data Processing

The raw EMG traces were exported into Delsys EMG Works™ Version 4.3.2 for analysis. An initial bandpass filter embedded in the processing software (www.delsys.com/emgworks) was applied to the data to remove noise (5-420Hz) which could alter the processing and analysis (De Luca et al., 2010). Any trials not reaching 60 seconds or having clear abnormalities as detailed in the inclusion criteria (Table 2) were securely discarded (Walker et al., 2014). Visual assessment identified the first eight consecutive peaks representing the onset and offset of muscle activity, and these were isolated and quantified, an approach which has been validated by Zsoldos et al (2010) for the purpose of identifying muscle activity within repeated measures. To allow for further comparison between trials, integration of the full wave rectified signal (iEMG) was performed to determine the percentage of difference to maxima for contractions (Hug, 2011; Delsys®, 2013). The same process was then repeated for post treatment trials, (Hug, 2011). Amplitude minima, amplitude maxima and amplitude mean of the first eight peaks of each trial were measured and recorded in MS Excel 2019 (Microsoft, Redmond, WA, USA) prior to statistical analysis. Median±IQR and the percentage change from pre to post treatment trials GS were calculated.

Table 2: Data inclusion and exclusion criteria

Data Inclusion Criteria	Data Exclusion Criteria
Horse standing square during collection	Hind legs uneven during collection
Neutral head and neck positioning during collection	Head and neck position elevated or drastically lowered
60 seconds of recorded data for each trial	Movement during collection
	Electrode not flush with skin or adhesive comes loose during or immediately after collection
	Horse exhibits anxious behaviour during collection

Statistical Analysis

Data were analysed using Statistics for Social Scientists (SPSS, Version 26; Chicago, IL, USA). Data met non-parametric assumptions in a Kolmogorov-Smirnov test ($P \leq 0.05$)(Liang, Fu and Wang, 2019; Yilmaz, 2019) therefore a series of Wilcoxon Signed Rank analyses determined if significant differences occurred from pre-treatment (PreTx) to post-treatment (PostTx) values in peak iEMG contractions, for individual horses and across the cohort (van Doorn et al., 2020). Due to the potential for type I errors or false positives, given the sample size and repeated trials, a post hoc Bonferroni correction was applied resulting in a revised significance of $P \leq 0.02$ (Chan et al., 2020). The Bonferroni adjustment was required due to aspects such as discipline, age and sex that cause an inherent variability between horses (North and Hoffman, 2017; Vermeulen et al., 2017). Reliability between trials was assessed using Cronbach's Alpha (de Vet et al., 2017). Friedman's analysis with post hoc Wilcoxon Signed rank analyses tested if differences occurred between trials across the cohort (significance: $P<0.05$) (Lopez-Vazquez and Hochsztain, 2019).

Results

Across the cohort, a reduction in muscle workload and maximum contraction occurred in (GS) responses after treatment (PostTx)(Left: 1.41 ± 0.02%; Right: 0.09 ± 0.2%); these changes were statistically significant on the left side (ANCOVA: $P \geq 0.02$). Reliability of repeated measurements within horses and across the cohort was poor (Cronbach's Alpha coefficient: 0.33; $P \leq 0.02$). All data below are presented as medians ± interquartile range (IQR) unless otherwise stated.

Cohort Results

Across the cohort, horses recorded a reduction in normalised maximum dynamic contraction PostTx (0.02 ±5.81%) compared to PreTX trials, however this was only found to be significant on the left side ($P \leq 0.02$). Across the cohort, 64% of horses (n=7) exhibited a decrease in muscle motor neuron activity (MNA) from PreTx to PostTx trials on the left GS (PreTx: 9.52 ± 0.76; PostTx: 6.83 ± 2.04). This percentage increased for the right GS, where 73% of horses recorded a decrease (n=8; PreTx: 9.82 ± 0.55; PostTx: 9.65 ± 0.54). The reported changes were bilateral in 82% of the horses (n=9), with 78% of these (n=7) exhibiting a negative change (Table 3). It should be noted that a high degree of variability was observed in muscle MNA, both within and between horses across the cohort, in the PreTx and PostTx trials.

Table 3: The mean percentage of difference in muscular workload within each horse from PreTx to PostTx trials. Laterality or handedness of difference in magnitude shows intra-horse side differences.

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Individual Horses

GS MNA decreased sequentially across the three trials or decreased by trial three from pre treatment readings in all horses except horses four and six. This reduction occurred across all other subjects, but the magnitude of responses varied based on the individual (Table 3, Figure 2). A pattern of differences in muscle MNA occurred between each PostTx trial: Trial 1: 9.62 ± 3.11; Trial 2: 8.23 ± 2.38, a 14.4% reduction from trial one; Trial 3: 4.75 ± 3.85, a 42% reduction from trial two and a 51% reduction from trial one. Irrespective of these trends, there was no significant difference between the trials (Friedman's: $P>0.05$).

Intra-Subject Trends

Variation in stimulated muscle activity was observed across horses, with the majority of horses demonstrating a larger change on one side compared to the other. Horse one presented with the largest negative change out of the cohort from pre-treatment (PreTx) to post treatment (PostTx) on the right GS (5.81%) (Figure 2) and horse five exhibited the largest negative change on the left GS at 5.55%, however in this case the right side change was marginal at 0.03% (Table 1, Figure 2). Horse two showed the smallest percentage change on the right GS at 0.02%, but the left GS was the second highest negative change at 3.63% (Figure 2). While the majority of MNA percentage changes were bilaterally negative, in 64% of horses (n=7) one side differences were marginal (≤0.04%) and the other side experienced > 2% change (Table 1). Horse 11 was unique in that it showed nearly identical negative changes bilaterally, with the left presenting a -2.76% difference and the right a -2.9% difference from PreTx to PostTx. Horses 6 and 9 were the only individuals to both present bilateral positive changes (Table 3, Figure 2).

Figure 2: Median Amplitudes PreTx and PostTx for horses one, two, five, six, nine and eleven.

Discussion

Significant differences in muscle MNA were only identified on the left side between pre and post ETT treatment, however an overall trend for reduced MNA post treatment was observed. The primary proposition for this unilateral response is that the left side was treated first across the cohort, and the ETT may have had contralateral effects, leading to a smaller measured change within the right side (Minetto et al., 2018). Research has identified that contralateral exercise improved range of motion, which can be justified within the bilateral fascial connections (Fermin et al., 2018). This link may explain why the left side, which was treated first, showed significance after the Bonferroni adjustment and the right side did not if the effect of the treatment crosses the sagittal plane via the fascia (Scott and Swenston, 2009). Simultaneous measurement of both left and right hand sides of muscles would be beneficial in future studies to identify the full influence of the treatment.

While statistical significance has provided a universal framework for researchers, when analysing determinants of performance, small changes can translate to functional differences being observed, despite no significant differences being recorded (Quintana, 2018). Therefore although significance differences in MNA were not present in all parts of this sample, the descriptive differences observed could be indicative of functional changes occurring in the muscle in response to ETT accordance representing minimum clinically important differences (MCID) (Copay et al., 2007; Ruhdorfer, Wirth and Eckstein, 2015) and contributing to overall performance gains within the context of marginal gains theory (Quintana, 2018). The determinants of MCID are subjective, patient led responses which identify the smallest change that is considered worthwhile (Torrens, Guirro and Santana, 2016; Sedaghat, 2019). Due to the subjective nature of this measure, it is not possible to determine this in the horse apart from the view of the owner or rider, however it is a consideration in evaluating the controversial correlation between statistical significance and functional improvement (Guzik et al., 2019; Okoroha et ak., 2019).

Marginal Gains Theory

The marginal gains theory postulates that improvements in individual areas by just 1% can accumulate to a large improvement in performance (Hall, James and Marsden, 2012). Therefore with this approach, change may still be meaningful when unaccompanied by a significant visible outcome, as consistency comes from the aggregation of multiple marginal gains (Durrand, Batterham and Danjoux, 2014). This method has been widely accepted in biomedical science, relating marginal gains to enhanced recovery after an operation (Fleming et al., 2016; Khuddus, Truesdell and Kirtane, 2020; Leng and Mariano, 2020).

Within this study, the horses underwent a full body treatment after data collection, but for the purposes of this study, only data from the GS was recorded. With significant effects being seen on the left side, marginal gains may be achieved through each treatment with the ETT; the aggregated effect in multiple muscles may result an improvement in functionality and overall performance (Nierenberg et al., 2015; Chapman et al., 2016; Liyanage, 2017). The majority of horses exhibited marginal changes in GS muscle MNA, either unilaterally or bilaterally within one 15 minute ETT treatment. The GS is only one muscle in a large interlinked system in the horse, it is possible that this change among multiple muscles produced during a full body treatment may contribute to functional changes (Leisson, Jaakma and Seene, 2008).

Trends Observed

One of the objectives in this study was to identify whether changes produced by the ETT were sustained for more than 60 seconds post treatment. PostTx trials recorded reductions in GS MNA lasting into trial three, which began at three minutes PostTx; however these decreases were not found to be significantly different to PreTx values. The time period used here may not have been sufficient to provide a full picture of the effect of treatment, thus future research with a longer observation may exhibit effects lasting for more than four minutes as well as long term impact needed to substantiate beneficial results of treatment (Pool and Laubscher, 2016). A trend of right-side laterality was observed in the subjects who competed in polo, who had greater changes in maximal contraction PostTX in the right *GS*, consistent with the common side of the rider's swing and the unilateral compensation and fitness (Brydon, 2016).

Rehabilitation Versus Maintenance

Within this study all horses were required to have no clinical signs of pain and the participants were certified by the veterinarian to not be undergoing therapy for rehabilitation purposes which may have impacted the results (Khalilzadeh and Tasci, 2017). Treatment for the purpose of maintenance is likely to be used to sustain current performance capabilities, thus horses are already at an appropriate level of fitness and functionality (Goff, 2016; Tabor, 2018). While this may be true, the effect of high intensity exercise as seen in training and competition of the equine athlete often results in muscle fibre damage and associated soreness in the muscle (Hedayatpour, Izanloo and Falla, 2018). This may be observed in the changes seen in individuals who had just completed their competition season at the time of data collection, along with those who had been treated every six weeks for the past 12 months where only minor adjustments were needed.

Limitations

Due to the external nature of sEMG there was variability between each animal, as exhibited by the poor results of the Cronbach's alpha (32.8%). This may result from the reduced reliability seen in EMG when used outside of temporal measures (Lowery, Stoykov and Kuiken, 2003; Felici, 2006). Factors that influence sEMG signal acquisition include body fat percentage, which may alter the ability of the signal to reach and return from the muscle effectively, giving skewed results (Felici, 2006; Williams, 2018). Similarly, the fitness level and muscle fibre type are important considerations due to their individuality and influence on recruitment patterns and neuromuscular connectivity (George and Williams, 2013; Williams, 2018). Within the demographics of the horses included, there are differences in each of these factors such as muscle fibre type variations due to differences in disciplines (McLean and McGreevy, 2010; Williams, 2018). Equine and human research has shown that EMG signals are highly individual (Patterson-Kane and Firth, 2009; Williams et al., 2014; Williams, 2018), therefore a within-subjects design was applied, with each subject acting as their own control (pre-Tx reading) and data collected within a single session to limit their influence on the results. The methods used optimised data quality (Felici, 2006), however it should be acknowledged that the use of one sensor on each muscle gives only a single snapshot of a limited cross section of muscle fibres. With the large size of the *GS*, the sensor must be placed with awareness of topographical specificity in order to avoid cross talk from other muscles and tendinous insertions (Williams, 2018). Although using only one sensor may have been a disadvantage, sEMG sensors do allow observation of more motor units than needle methods (Wijnberg et al., 2003). The goal of measuring changes in horses during maintenance treatments may have introduced a limitation due to the effect size likely being smaller and more difficult to identify than in a rehabilitation setting (Khalilzadeh and Tasci, 2017). The possible impact of laterality may suggest that randomising the order of treatment would yield more consistent results, whereas this study treated the left GS first on every individual. If laterality and contralateral effects were controlled for, differential effects from those observed in this study may be observed.

Conclusion

A reduction in motor neuron activity of the GS was found in 82% of horses after ETT treatment, however these changes were only significant on the left side. Due to this, the primary suggestion for future research is to randomise the side on which the treatment session begins and to assess the impact bilaterally throughout the entire duration of data collection. Future research should also consider the timeline of data collection in an effort to ascertain whether there are long term benefits and how long the effects of treatment are maintained in the muscle. It may be useful to narrow the participant criteria to further control for limiting factors such as discipline, timing of data collection in reference to competition season, and body fat percentage. While inferences may be made as to how these data reflect the impact on the GS, further work studying the effects of ETT must consider the skeletal system as a whole.

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Figure Legend:

Figure 1-Page 3: Experiment set up during treatment between pre-treatment and post-treatment trials. In this image, the therapist is treating the hindquarter with the handheld device which is connected to the metal plate on the wither; the sEMG sensor can be seen above the practitioner's hand.

Figure 2- Page 6: Median Amplitudes PreTx and PostTx for horses one, two, five, six, nine and eleven.