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Electromyography of the multifidus muscle in horses trotting over firm and soft surfaces

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ABSTRACT

Equine sports medicine has developed a focus on the multifidus muscle with little reported knowledge of its activity in normal horses. Our main aim and objective was to use in-dwelling electromyography (EMG) to measure and compare the average and peak activity of the multifidus muscle at the level of the 12th (T12) and 18th thoracic (T18) and 5th lumbar (L5) vertebra bilaterally. We hypothesized that trotting horses in hand over a soft deformable surface would cause an increase in both average and peak activity when compared to trotting on a non-deformable asphalt surface. The EMG signals from four horses each with 25 observable muscle contractions at each location were filtered and normalized to the maximum observed signals. The effect of two surface conditions on the average and peak muscle activity within each muscle section of four horses was assessed using unpaired t-tests. The average muscle activity was significantly higher while trotting over a soft surface when compared to the hard asphalt surface in the right T12 (mean difference [MD]=0.13 $p < 0.001$), right L5 (MD=0.12 $p < 0.001$) and left L5 (MD=0.18 $p < 0.001$) regions, although the left T12 location showed significantly higher average activity on the hard surface (MD=0.13 $p < 0.001$). The peak activity was significantly higher on soft footing in the left T18 (MD=0.10 $p < 0.05$), left L5 (MD=0.18 $p < 0.001$), right T12 (MD=0.40 $p < 0.001$), and right L5 (MD=0.10 $p < 0.001$). Therefore, when compared to trotting on a hard surface, the softer surface induced higher levels of muscle activity in most of the multifidi locations.

1. Introduction

Core strength is of vital importance in the maintenance of performance and the prevention of injuries in horses [1]. Biomechanically, the horses' back is thought to act as a "bow" consisting of the vertebral column, pelvis, and associated musculature [2]. The bow is kept under tension by the "string" formed by the sternum and abdominal muscles [2]. In the bow and string model, the epaxial muscles representing the "bow," and are comprised of the erector spinae and multifidus muscle groups. Based on this, equine practitioners have placed similar focus on the multifidus muscle as human medicine. However, the activation of the multifidus muscle has not been studied extensively and the effect of different training and rehabilitation exercises on multifidus activity remains largely unknown.

In humans, the spine stability is believed to be achieved by the activation of the transversus abdominis, lumbar multifidus and erector spinae muscle groups [3–5]. The multifidus muscle group lies on either side of the dorsal spinous process [6]. It has several fascicles that attach the mammillary process of one vertebra to the dorsal spinous process of another vertebra. Fascicles can span, from one to four spinal segments, with longer fascicles lying more medially than shorter underlying fascicles [6]. In horses, the multifidus muscle has five distinct fascicles sharing a common cranial attachment with distinct and independent insertions caudally [7]. Each fascicle has bands that can span from one to four intervertebral discs [7]. Deeper bands connected fewer vertebral segments than more superficial bands, similar to what is seen in humans [6,7]. Both humans and horses also have terminal insertions upon the sacrum [6,7]. However, horses have a continuation of the multifidus referred to as the sacrocaudalis dorsalis, that continues caudally and contributes to the control of the tail [7].

Humans with lower back pain have benefited from therapeutic exercise programs that focus on trunk muscle strengthening,

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proprioception training, and balance control [8–13]. One method used in human exercise plans to achieve these goals is to exercise on an unstable surface. It is thought that greater instability of the body-ground surface interface would induce greater challenges to the neuromuscular control system [14]. Research has shown an immediate increase in trunk muscle activity in humans performing squats on unstable surfaces [14]. While impractical to ask horses to exercise on truly unstable surfaces, such as inflatable balance balls, it has been shown that changes in surface impact density can alter joint range of motion in the limbs [15] and that softer and deeper surfaces with less impact density induce more work from propulsive muscles [16,17]. Changes in trunk biomechanics or muscle activity based on surface type is yet unreported despite equine athletes being asked to perform exercises on various surfaces.

Electromyography (EMG) is a technique that allows the recording of myoelectric signals [18]. Muscles are composed of separate motor units consisting of the alpha motor neuron, its axon, the motor end plate and the individual muscle fibers it innervates [18]. A functional approach to EMG specifically refers to the recording of the summation of electrical activity of each motor unit, also referred to as the motor unit action potential [18]. There are two basic methods to capture this electrical signal, using intramuscular electrodes or surface electrodes. Intramuscular electrodes are implanted directly into the desired muscle of study, whereas surface electrodes are attached to the surface of the skin over the muscle [18]. Intramuscular in-dwelling electrodes show high specificity of measurement, and with proper insertion and placement techniques, they are less susceptible to crosstalk signals from other muscle groups, and they are the only method available for measuring the activity of deeper muscles [19] such as the multifidus. Various processing methods for equine EMG have been assessed [20] with average rectified (ARV) and peak values (PE) being commonly reported to quantify muscle activity in equine research [19,21–28]. The ARV represents the overall activity which is found from the rectified EMG signal over a specified time interval [20,22,29], whereas PE indicates the highest signal detected, or peak muscle activity, within a specified time interval [20,22,29].

Despite claims that the multifidus muscle is of great importance for spinal stability in horses [1,26,30], there are no data on multifidus muscle activity in sound horses whilst trotting on different surfaces. Previous work using EMG in the multifidus has shown a varied magnitude of response throughout the muscle when horses were asked to perform different therapeutic exercises on a single surface [29], thus multiple sampling sites are indicated for a complete assessment of the muscle. The purpose of this study was to determine the activity level of the multifidus muscle in six different locations while horses trotted on firm and soft surfaces. Our objectives were to use indwelling fine wire EMG electrodes to determine the average and peak muscle activity of the multifidus muscle at the 12th (T12) and 18th (T18) thoracic, and 5th lumbar (L5) dorsal spinous process bilaterally. We hypothesized that the multifidus would show a greater amount of average and higher peak muscle activity when horses trotted on a soft arena footing when compared to a hard asphalt surface.

2. Materials and methods

2.1. Horses

The University of Tennessee Veterinary Research and Teaching Center provided horses for the study. Horses were deemed acceptable for the study if they demonstrated a consistent two beat diagonal trot gait and did not show lameness greater than a grade 2 lameness based on the American Association of Equine Practitioners lameness scale. At the time of data collection, all horses received oral phenylbutazone at a dose of 2.2 mg/kg twice daily starting the morning before data collection (3 doses total) to eliminate any residual lameness. This study was performed in accordance with the Association for Assessment and Accreditation of Laboratory Animal Care and United States Department of Agriculture guidelines with approval from the University of Tennessee Institutional Animal Care and Use Committee; protocol #2659.

One gelding and three mares aged 4–14 years of various breeds from the University of Tennessee Veterinary Research and Teaching herd were used. All horses showed a grade 1 or 2 lameness in one limb on initial baseline exam; however all were visually sound during data collection as deemed by two authors (TU, KS) experienced in assessing lameness.

2.2. Gait event detection

In order to extrapolate a repeatable gate event, optical motion capture analysis was linked to the activity of the longissimus muscle using surface EMG on asphalt in one horse. However, the motion capture was not able to be performed on the soft surface.

To detect a repeatable gait event on asphalt, a simple marker set using spherical reflective markers placed on the lateral aspect of each hoof at the level of the coronary band was used. To detect longissimus dorsi muscle activation, self-adhesive surface electrodes with an inter-electrode distance of 2 cm were adhered to clipped, shaved, and cleaned skin overlying the muscle at the level of the dorsal spinous process of the 16th vertebrae bilaterally. Surface electrodes were connected to EMG sensors using an alligator clip connector (DTS surface lead connector, Noraxon USA, Scottsdale, AZ). Motion analysis was collected using Nexus (Vicon Motion Systems, Oxford, England), which was synchronized with the EMG signal recorded from the telemetric system (Myomotion; Noraxon USA, Scottsdale, AZ).

Kinematic data from both motion capture cameras and electromyography were exported into Visual3D (C-Motion Inc., Germantown MD) for further processing. Kinematic data were low-pass filtered with a cut off frequency of 8 Hz. Raw EMG signals from the longissimus were processed as previously described [20,22,29] with a high-pass filter set at 40 Hz, followed by rectification and finally a low pass filter with a 15 Hz cut off frequency.

Gait cycle events of each limb were labelled based on when reflective skin markers reached the minimum position in vertical displacement. Each gait event for each limb was related to the synchronized EMG activity of the longissimus dorsi muscle. The left longissimus muscle was determined to have two isolated peaks of activity on the final enveloped data per single trot gait cycle consistent with previous reports [28].

This was collected prior to and separate from the multifidus data in order to confirm that the method and location of longissimus EMG signal acquisition produced similar findings to that previously reported [28]. Confirming the number of muscle activations longissimus muscle, allowed for identification and counting of strides that could be extrapolated to the multifidus muscle on all horses over both surfaces.

2.3. Instrumentation and data processing

Horses were instrumented as previously described [22,29]. Briefly, diagnostic ultrasound was used to identify each dorsal spinous process of the thoracolumbar spine of each horse. The skin at each location of each sensor was clipped, shaved, and thoroughly cleaned.

Subcutaneous mepivacaine was used to desensitize the skin while staying superficial to the thoracolumbar fascia to prevent alterations in thoracolumbar muscle function as previously reported [31]. The preloaded 23-gauge 75 mm length needles (Chalgren Enterprises, Gilroy, CA) were aseptically inserted through the skin and visualized with ultrasound guidance into the multifidus at the junction of the middle and deep third (Fig. 1). The hook ends allowed the electrodes to remain embedded in the muscle tissue and the needle was removed. To prevent possible damage to the electrode ends, needles were replaced with a new needle-electrode set if not placed correctly on the first attempt. No redirection of the needles was allowed. Electrodes were placed at the level of the dorsal spinous process of the twelfth (T12) and eighteenth thoracic (T18) and fifth lumbar (L5) vertebrae bilaterally. Using a screw

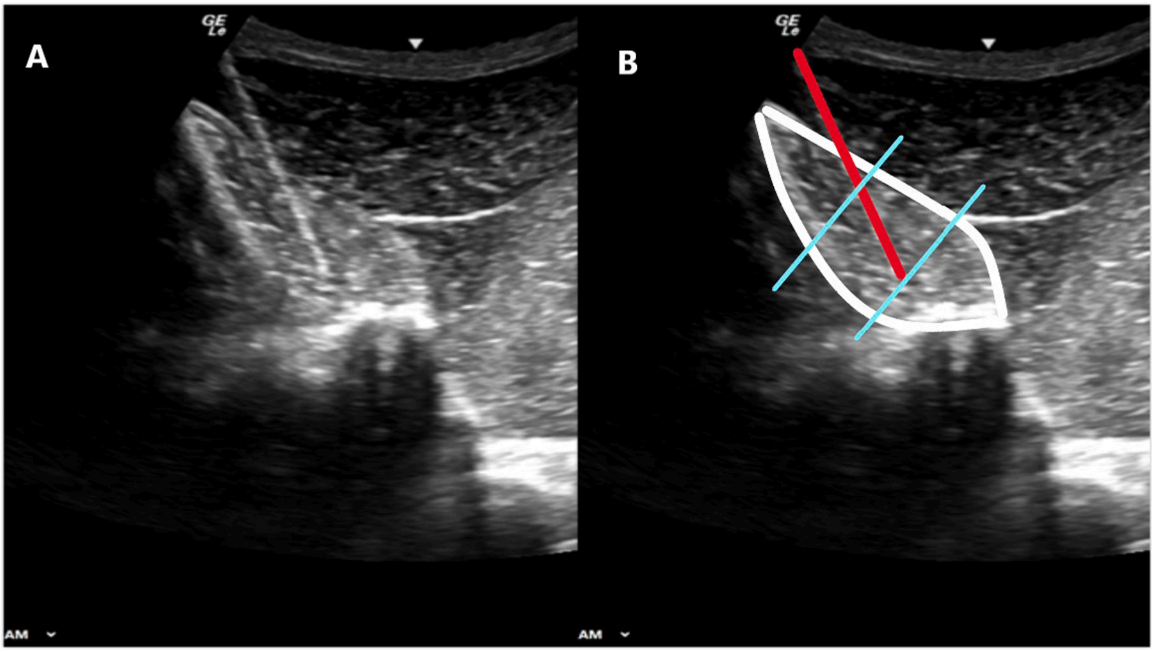

Fig. 1. Panels (A) and (B) show the same diagnostic ultrasound image. Panel (B) shows the outline of the multifidus muscle (white border). The fine wire electrodes are delivered via the 23 gauge needle (red line) with the electrode ends embedded at the junction of the middle and deep thirds of the muscle belly (blue lines).

post and nut device (DTS Fine wire lead connector, Noraxon USA, Scottsdale, AZ) wires were connected to the EMG sensors.

To detect longissimus dorsi muscle activation, self-adhesive surface electrodes with an inter-electrode distance of 2 cm were adhered to clipped, shaved, and cleaned skin overlying the muscle at the level of the dorsal spinous process of the 16th vertebrae bilaterally.

A telemetric unit (Myomotion; Noraxon USA, Scottsdale, AZ) was used to collect synchronized muscle activity from the multifidus and longissimus muscles with a sampling frequency of 1500 Hz.

Raw EMG signals from the multifidus and longissimus muscles were exported into Visual3D (C-Motion Inc., Germantown MD) for further processing as previously described [20,22,29] with a high-pass filter set at 40 Hz, followed by rectification and finally a low pass filter with a 15 Hz cut off frequency. In the four subject horses, the boundaries of six complete activations from the enveloped data of the longissimus muscle were counted and labelled to determine the boundaries of 3 strides within the data set. Five of these three-stride segments were labelled within the entire data set for both surfaces. High speed video camera footage (NiNOX Video Capture; Noraxon USA, Scottsdale, AZ) collected at 125 Hz and synchronized to the EMG signal was used to ensure that the ten total segments selected (5 on each surface) did not include portions where the horse obviously changed pace, moved laterally, or changed their head position greatly.

Since the activity of both the longissimus and multifidus muscles was synchronized, the boundaries of the five three-stride segments were automatically labelled on the data of every muscle and location sampled. Within all five segments, every sampling location of the multifidus showed a total of 25 activations. Using the final enveloped signal, the onset and offset of every activation was labelled by hand for every activation at each muscle location, on both surfaces, in each of the four horses by the same author (TU) to ensure consistency. Visual3D maintained these labels throughout the processing steps, therefore the exact location of the start and stop of each activation was automatically labelled on the average rectified signal which was used to determine the ARV.

For each sampling location the average rectified value and the maximum enveloped value were normalized to their respective maximum observed signals across all trot strides, i.e. the maximum observed EMG signal across all trot strides for each horse, at each multifidus site, across all conditions. The average rectified signal was used to calculate the average activity of each activation of the multifidus muscle, represented as the average rectified value (ARV) [32,33], and the maximum value of each activation using the final enveloped data represented the peak muscle activity (PE) [32,33].

2.4. Exercises

EMG signals from both the multifidus and longissimus muscles were collected with the horse trotting straight in hand on a hard asphalt surface and on a soft synthetic arena surface (Footing First, Purdys, NY) for a minimum of six repetitions of 15 consecutive strides. All exercise repetitions for both surfaces were performed on the same day without removing the sensors. The order of surfaces was randomized for each horse based on a simple coin flip. Pace was subjectively maintained by ensuring each horse was traveling at a relaxed consistent trot and the same handler was used for every trial run on both surfaces.

2.5. Statistical analysis

For each of the 25 observed muscle activations, at each location, for each condition, in four horses, the ARV and PE were calculated. The difference in mean values for ARV and PE in each muscle section were compared within each horse on both surfaces using unpaired t-tests across all observed gait cycles for all four horses (SPSS version 27). Data were assessed using the Levene's test for equality of variances followed by the appropriate t-test for equality of means and results were reported using a 95% confidence interval at a significance level of $p < 0.05$.

3. Results

3.1. Multifidus electromyography

The multifidus muscle activity was 95% and 87% greater in soft footing when compared to the hard surface for the right T12 location for both AV and PE EMG respectively ($p < 0.001$). Similarly, both L5 regions showed significantly greater muscle activity in soft footing, with approximately double the activity for both ARV and PE ($p < 0.001$), and PE was 20% greater in soft footing in the left T18 ($p < 0.031$) However, ARV was significantly greater on the hard surface for the left T12 region with 26% greater activity ($p < 0.001$), and PE at left T12, ARV at left T18, and both PE and ARV at right T18 showed no significant differences between the two surfaces (Table 1).

4. Discussion

Our main purpose was to compare the muscle activity of the multifidus while horses were trotting on hard and soft surfaces. These exercises are common in all conditioning and exercise programs, regardless of the horse's intended use or purpose. This work is the first step in determining overall muscle activity of the multifidus muscle during a routine exercise, such as the trot. The multifidus muscle was selected due to its theorized role as a spinal stabilizer in other quadrupeds [30, 34,35]. The multifidus muscle has been emphasized in horses due to atrophy noted adjacent to areas of spinal disease post-mortem [36]. However, there have been no reports indicating the activation of the multifidus during motion in sound horses without clinical evidence of back pain.

We found significant differences in either average or peak muscle activity in all muscle sections except right T18. Interestingly, left T12 was the only muscle location in which the softer footing induced a significant decrease in ARV only as compared to the hard. This could be due to the left sided location of the handler when horses trot in hand. Despite not showing obvious changes in head or neck position, small changes in position could have occurred which may have contributed to altered muscle activity.

Human studies have shown significantly greater mean activity of the muscles responsible for ankle stabilization when people were asked to exercise on an unstable surface [37]. Additionally, an unstable surface increased activity of all trunk stabilizing muscles by 37–54% [38]. Other researchers confirmed these results on trunk muscles specifically in the lumbar [39], and abdominal musculature [40,41]. Pinnington et al. investigated the changes in surface EMG of the hamstrings, quadriceps, and tensor fascia latae muscles when runners were asked to perform in sand versus a firm wooden floor [42]. Significant increases in average muscle activity as well as a calculated energy cost was observed in all muscles when running on sand [42]. Despite the inability to assess horses exercising on truly unstable surfaces, such as inflatable balance balls, it has been shown that changes in surface impact density can alter joint range of motion in the limbs [15], however changes in EMG for any muscle has not been reported in horses on varying surfaces. Nor can synthetic arena footing be directly compared to the sand surface investigated in humans [42] without further study. Additionally, there are large obvious anatomic differences between horses and humans. While many concepts in human mechanics and exercise are immediately extrapolated to horses, caution should be taken when comparing quadruped and biped biomechanics, especially in relation to spinal and limb stabilizing techniques. While the multifidus muscle function has not been adequately reported in horses, it is important to note that we have reported similar findings in this study as seen in the human literature. The increased activity of the multifidus muscle, especially in the lumbar region seems to indicate a potential need for increased spinal stability when horses trot on soft surfaces. Further study in this area is required.

Traditionally, most equine research on surface conditions has investigated the hoof-surface interaction [43,44], or the characteristics of the surface itself [45], with little to no reference to muscle activity. The only equine study comparing motion in horses trotting on firm sand and deeper unstable sand, showed that the deeper sand resulted in decreased efficiency of pushoff, implying that propulsive muscles must require more force to propel forward [17], however, this was not confirmed with EMG. The same research group investigated the use of qualitative ultrasound and speed of sound measurements as a way of determining the force produced by a tendon [16]. When comparing two surfaces, the force produced by the superficial digital flexor tendon was greater in the surface that was softer and more easily deformed [16]. In ex-vivo studies, tendon force was directly related to the strength of the muscle contraction due to the elastic nature of flexor tendons during the stance phase [46]. However, this research does not incorporate the effects of the "stretch reflex" during which stretching of a tendon will induce a muscle contraction via a protective mechanism [47]. Therefore, there could be an association between the increased force produced by the tendon and an increase in muscle activity on the softer surface.

Table 1
Normalized mean (standard deviation) values (n = 25 activations in each of 4 horses) for outcome measures on hard and soft surfaces.

Muscle	Outcome Measure	Hard Surface Mean (sd)	Soft Surface Mean (sd)	p value for equality of means (2-tailed)	Mean Difference	95% Confidence Interval Lower	95% Confidence Interval Upper	% change Ŧ
Left T12	Average rectified	0.50(0.19)	0.37(0.25)	**< 0.001 ***	0.13	0.066	0.19	-26%
	Peak Envelope	0.53(0.18)	0.47(0.33)	0.111	0.060	-0.0140	0.13	-21%
Right T12	Average rectified	0.39(0.21)	0.77(0.46)	**< 0.001 ***	-0.37	-0.47	-0.27	95%
	Peak Envelope	0.45(0.22)	0.85 (0.49)	**< 0.001 ***	-0.39	-0.50	-0.29	87%
Left T18	Average Rectified	0.41(0.23)	0.46(0.31)	0.199	-0.051	-0.12	0.027	12%
	Peak Envelope	0.47(0.24)	0.57(0.38)	**0.031 ***	-0.098	-0.18	-0.0089	20%
Right T18	Average Rectified	0.31(0.21)	0.29(0.26)	0.515	0.021	-0.044	0.088	-7%
	Peak Envelope	0.36(0.22)	0.38(0.29)	0.542	-0.022	-0.095	0.050	6%
Left L5	Average Rectified	0.18(0.20)	0.36(0.28)	**< 0.001 ***	-0.17	-0.24	-0.10	98%
	Peak Envelope	0.13(0.13)	0.32(0.32)	**< 0.001 ***	-0.18	-0.25	-0.11	130%
Right L5	Average Rectified	0.12(0.13)	0.24(0.15)	**< 0.001 ***	-0.12	-0.16	-0.080	98%
	Peak Envelope	0.10(0.092)	0.19(0.14)	**< 0.001 ***	-0.097	-0.13	-0.063	96%

Bold* denotes significant differences between surfaces ($p < 0.05$)
Ŧ- a positive value indicates soft > hard, a negative value indicates soft < hard

Our work showed similar outcomes, especially in the lumbar regions, in which the surface with less impact density reported significantly higher peak and average values of muscle activity. More research should be done to link the overall trunk motion to the activity of the multifidus muscle in order to further elucidate the mechanism of muscle activity.

The average and peak muscle activity of the multifidus was significantly increased in both lumbar regions when horses trotted on the soft surface with a lower impact density. If the current proposed function of the multifidus acting as the primary spinal stabilizer [1,36] is to be believed, then an increase in activity would indicate an increase in spinal stability. Therefore, when horses trot on softer surfaces, there must be an alteration in kinematics of the spine as compared to surfaces with a higher impact density. This change of mechanics could be related to an increase in axial rotation, lateral bending or flexion and extension in the sagittal plane. Unfortunately, a complete three-dimensional motion analysis with six degrees of freedom comparing motion of the equine spine on different surfaces has not been reported. There are several reports that indicate measurements in three dimensions, however, when one fully investigates the methods, a full six degrees of freedom of multiple spinal segments is not available without invasive methods [48–50].

The significant findings in the lumbar region could be of great clinical relevance. The caudal thoracic and lumbar spinal regions are most implicated in the development of pathologic processes such as overriding dorsal spinous processes or "kissing spine" and osteoarthritis [36,51–53]. If horses show an increase in multifidus activity in these regions, indicating a need for increased spinal stability, then changes in motion could be related to why horses develop lesions in these regions. Horses with weakened multifidi muscles may also be at increased risk of injury on softer footing if they are unable to achieve adequate spinal stability in these regions. The model employed here is inadequate to make any conclusions on spinal motion, however the changes in muscle activity reinforce the need for further study in this area.

It should be noted that the overall normalized mean values detected in the multifidus are overall low in amplitude. This could be due to the normalizing method of comparing to the highest reported signal at each site. Despite significant findings, the changes in muscle activity of some horses may not result in clinical significance. Additionally, EMG analysis of the multifidus muscle in horses is in its infancy. Given that the multifidus muscle is predicted to be an intersegmental spinal stabilizer [1, 7], with a fairly small cross-sectional area in relation to the overall body mass of the horse, overall changes in electrical activity may be smaller than expected for larger propulsive muscles. It should also be highlighted that the function and overall activity of the multifidus muscle has not been established in horses. However, research in dogs has indicated that the multifidus contributes to spinal stability [34], although the anatomic structure of supportive soft tissues and range of motion of the spine varies greatly between dogs and horses, and therefore should not be directly extrapolated without further validation.

Specific limitations of this work include the inability to link the activity of the multifidus muscle to phase of stride. Therefore, it is impossible to determine if the timing of muscle activation was altered on the different surfaces. However, this was not a primary objective of this study. In this study we used the longissimus muscle activations to label and extrapolate the data set. It is not expected that the number of activations per stride would change on different surfaces, but the timing may. However, this is not expected to change the conclusions made on average and peak muscle activity. Additionally, the multifidus muscle is comprised of several fascicles, each of different length. Care was taken to implant each electrode at a similar location of each multifidus site, at the junction of the middle and deep thirds. However, since the different fascicles are not ultrasonographically apparent, some electrodes may have been positioned within different fascicles than others. While the anatomy is well documented [7,54], the function of each fascicle has not yet been determined. Hyytiainen et al. has shown variation of muscle fiber types between fascicles in horses as well as breeds [55], and muscles have been documented to have altered fiber type, based on the forces and functions required [56]. Thus, there could be variation in EMG activity between fascicles. It also cannot be discounted that electrodes may have shifted during exercise, however no wires were seen to have backed out of the skin during data collection, and upon removal all wires appeared to still be at the original implantation depth. This work incorporates the use of four horses. Using all observations for every horse resulted in a calculated power of 1 at each muscle location for both ARV and PE. However, larger magnitudes of change could have become evident with more horses. Lastly, we were unable to standardize speed between trials, however, horses were maintained at their own natural pace for each exercise repetition and horses were given multiple rest periods throughout the data collection phase prevent fatigue. This is similar to previous methods used [22,29,57]. Additionally, each horse was maneuvered by the same handler throughout the study period, thus limiting the effect of variation from different handlers. While in hand trotting is not a typical exercise horses perform, the authors felt it was the most important first step in reporting the multifidus activity on separate surfaces. Trotting in circles on a lunge line on asphalt can be dangerous as horses are more likely to slip. Horses were given adequate length of rope while trotting so as the handler did not alter their natural way of going.

Future study should focus on integrating three-dimensional motion analysis with multifidus instrumentation to further explore the activity patterns during specific portions of the stride. Relating the EMG signal to stride characteristics and spinal motion would begin to define the role of the multifidus muscle in spinal stabilization in horses. If it is determined the multifidus contributes to spinal stability in a similar fashion as is seen in humans, further therapeutic exercise and rehabilitation methods should be investigated to maximize strength and function.

In conclusion, trotting on a soft surface induced higher levels of average muscle activity and peak activity values in most multifidi locations as compared to trotting on a firm surface. Reconditioning programs should consider incorporating exercise on varying density of surfaces, as the multifidus shows to have varied activation levels on the two densities of footing.

Ethical statement

The authors declare that all research presented within this manuscript is original and accurate to the best of their ability. There are no competing interests to report.

One author, H. Steve Adair is a member of the Editorial Board of the Journal of Equine Rehabilitation.

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All procedures included in this project were approved by the Institutional Animal Care and Use Committee of the University of Tennessee.

Portions of this manuscript have been previously published as part of a Doctoral thesis and the primary author maintains copyrights. It is not currently under consideration for publication elsewhere.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests. Co-author (H. Steve Adair) is on Editorial board for Journal of Equine Rehabilitation.

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