2020

The Effect of Whole-Body Vibration On Thermographic Readings of the Equine Back and Distal Forelimb

Megan Leclerc
megan.leclerc@otterbein.edu

THE EFFECT OF WHOLE-BODY VIBRATION ON THERMOGRAPHIC READINGS OF THE EQUINE BACK AND DISTAL FORELIMB

Megan N. Leclerc
Department of Equine Science
Otterbein University
Westerville, Ohio 43082

8 April 2020

Submitted in partial fulfillment of the requirements for graduation with honors

Sheri S.W. Birmingham, D.V.M. Project Advisor	____________________ Project Advisor's Signature
Steffanie V. Burk, Ph.D. Second Reader	____________________ Second Reader's Signature
John Tansey, Ph.D. Honors Representative	____________________ Honors Representative's Signature

TABLE OF CONTENTS

SECTION

ACKNOWLEDGEMENTS

I would sincerely like to thank the Otterbein Equine Department for their help and support during this project. Their assistance and cooperation, especially within the barn, with the requirements of the study made performing the research possible. Specifically, I would like to thank Dr. Sheri Birmingham and Dr. Steffanie Burk. Without their support and guidance, I would not have been able to complete this project. I have been grateful to be able to conduct research with such support at this institution. Funding for this project came from Otterbein University's Student Research Fund.

ABSTRACT

Modern horses are sophisticated athletes, which puts them at a high risk for injury. One therapy now being utilized is whole-body vibration. The purpose of this study was to examine the effects of whole-body vibration on the distal forelimb and the back of the healthy horse using thermography.

Data were collected over a 30-day period. Test horses stood on the vibration plate (n=10) 3 days a week for 30-minute sessions with the plate vibrating at 30-40 Hz. The control horses (n=10) received no treatment during the study. Baseline thermographic images were taken for all horses, and post treatment images were taken for the test horses. Images were taken of the proximal aspect of the distal forelimb and the longissimus dorsi muscle over the thoracolumbar spine. Mean surface temperature of test horses before and after treatment were compared using a dependent t-test with a significance level of $P<0.05$. Significant differences were noted for both the forelimb and the back, with lower post treatment temperatures. Independent t-tests were used to compare mean surface temperatures of control horses to post treatment measurements of test horses. A significant difference ($P < 0.05$) was noted between these values. Finally, a trend was noted between baselines of the test and control horses as determined by an independent t-test ($P < 0.05$). This study found significant changes in the surface temperature, used as an indicator of musculoskeletal inflammation, with the use of whole-body vibration treatment for 30-minute intervals, 3 days a week for 30 days.

INTRODUCTION

The equine musculoskeletal system consists of bones, cartilage, muscles, ligaments, and tendons all of which serve to support the body, provide locomotion, and protect vital organs (Adams, n.d.). Training and competition expose horses to uneven working surfaces, frequent concussion and stress on their joints and soft tissue structures, and generalized muscle strain and soreness. These unnatural forces put sport horses at a high risk for injury and subject the animals to chronic joint and musculoskeletal pain. Among the injuries sustained are torn tendons, joint effusion, muscle soreness and tightness and degenerative joint disease. Complementary and Alternative medicine have become prevalent in veterinary medicine. Alternative therapies, also known as holistic medicine, include different therapeutic options such as acupuncture, chiropractic, massage, magnetic therapy, laser therapy, and whole-body vibration therapy (Sumano et al., 1999).

Equine Anatomy and Physiology

Back pain is one of the most common and least understood ailments in horses (Harman, 1999). When carrying weight and equipment, horses experience an overall extension of the back, contributing to soft tissue injuries and diseased processes (De Cocq et al., 2004). This study will examine the thoracolumbar longissimus dorsi muscle (LD), the largest muscle in the equine back (Figure 1). It is one of three epaxial muscles in addition to the multifidus and iliocostalis which run in a longitudinal direction (Figure 2). The muscle originates at the ilium and inserts at the first thoracic vertebrae, lying superficially to the other epaxial muscles. It lies bilateral to the dorsal spinous processes and ribs (Ritruechai, 2008). Pain and injury of the thoracolumbar spine exist in the form of soft tissue injuries, primarily involving the longissimus dorsi (Cottriall et al., 2008). Back problems are seen in horses of all breeds and in all types of work (Wakeling et al., 2006) and thus are a main target area for research.

The structures of the proximal aspect of the distal forelimb are the carpal joints, the third metacarpal, the most proximal aspects of the second and fourth metacarpal, the first, second and third phalanges and the hoof itself (Figure 3). These are of particular interest due to the fact that horses naturally carry a greater amount of weight on their forehand than the hind end. (Duberstein, 2012). Due to the increased load bearing of the front end, it is an interesting question to see how the physics of their conformation may affect inflammation.

Whole- Body Vibration Therapy in the Equine Industry

Owners and practitioners are continuously trying to maintain the health of their horses by utilizing therapies such as chiropractic work, acupuncture, pulse electromagnetic field therapy, magnawave and whole-body vibration. Whole-body vibration dates back to ancient Greece where doctors would "pluck" a bow-like apparatus against the soldier's wounds in an attempt to stimulate drainage and expedite healing (Biomedj, 2018). In the late 1800's Swedish doctor named Jonas Gustav Zander, in developing the modern gym, created the "vibration machine" to stimulate weight loss and muscle gain in his patients (Biomedj, 2018).

Modern whole-body vibration (WBV) is considered a "passive exercise modality" by doctors and physical therapists. During treatment, patients stand, sit or lay down on a platform that vibrates in small movements in either an oscillating direction or a vertical direction. This action causes muscle contraction throughout the body, and thus is considered a form of exercise. A 2012 study done with humans found significant reductions in the plasma concentrations of inflammatory markers as well as increased in balance following whole-body vibration therapy sessions (Simão et al., 2012). It is suggested that vertical vibration shows better results clinically due to the fact that it directly counters the gravitational forces naturally experienced at all times. Vertical motion has shown to stimulate a more natural process and consequently holds less risk for injury or strain (Buchner et al., 2017).

In the past decade, veterinary practitioners have begun to utilize whole-body vibration in their practices for both small and large animal medicine to aid in clinical abnormalities similar to those in human medicine (Buchner et al., 2017). These include, but are not limited to, osteoarthritis, generalized lameness and neurologic deficits. There are now companies such as "Equivibe", "Theraplate" and "Vitafloor" that all offer whole body vibration plates to consumers. All of the plates marketed currently are about six inches tall, three feet in width and six feet in length making them simple for the horses to walk onto (Equivibe, 2019). The claims of all the products are similar, addressing issues of lameness, muscle soreness as well as performance recovery and preparation (Equivibe, 2019).

Thermography

Thermography will be used to qualitatively observe the changes in musculoskeletal inflammation. Thermography, as described by Soroko (2018) is a well-accepted diagnostic technique used to detect infrared radiation emitted from the surface of an object. Physiological processes, including inflammation and infection, produce heat (Chojnowski, 2017). Since body temperature is an indicator of normal or abnormal function, any altered body temperature is a natural indicator of disease (Chojnowski, 2017). A common feature of any physical examination is manual palpation for heat; however, thermographic imaging is at least ten times more sensitive to temperature changes than palpation by the human hand (Soroko, 2018). Thermography is currently being utilized in medical fields to diagnose, or aid in diagnosing, issues in large muscle groups and the limbs (Alfred 2015).

The lack of research surrounding vertical motion vibration therapy using thermography as a diagnostic justifies the need for this study. There are numerous equine studies that examine either vertical whole-body vibration or thermography, however the two modalities have yet to be studied in tandem. One study examined the effect of vertical whole-body vibration therapy on lame horses, finding no significant differences after two 30-day trials of whole-body vibration therapy (Halsberghe, 2017). A separate trial studied thermography as a diagnostic for lameness, discovering that thermal imaging of the suspected regions of acute cases helped the diagnosis in all cases but was not useful for chronic cases (Cetinkaya et al., 2012). Lastly, a study that examined whole-body vibration therapy as a muscular warm-up found no significant changes in muscle groups wen examined with thermography (Buchner et al., 2017). The researchers suggested that "different vibration protocols and vibration acting in the vertical direction might enable more effective exercise in horses" (Buchner et al., 2017). This research aimed to determine if the action of vertical whole-body vibration therapy is effective in reducing inflammation as monitored by surface temperature. The hypothesis tested was that test horses would have a decrease in surface temperature of the chosen structures following whole-body vibration therapy and that no changes would be seen in control horses.

MATERIALS AND METHODS

Otterbein University IACUC committee approval was granted prior to the start of this research. A total of 20 horses were randomly selected for participation in the study. The horses were randomly assigned to the control (n=10) or the experimental group (n=10). On treatment day 7, one of the test horses was diagnosed with a lameness in the hoof, leading to the removal of that horse from the study. This changed the experimental group from n=10 to n=9. No other injuries or lamenesses were reported during the study and the participating horses were used for the duration of the study.

Sample horses were all in the adult life stage (8-25 years of age), were geldings or mares, and varied in weight from 500 to 800 kilograms approximately. Breeds of the horses used varied as well (Thoroughbred, Warmblood and Warmblood crosses). All horses used were on a consistent diet of complete feed (Purina Senior, Purina Ultium or Purina Enrich) and grass hay. Mineral supplements and water were provided at libitum to all horses. Turnout of each horse varied (2-12 hours/day). The mean amount of work for the horses was 30 ± 14.17 minutes, 0.88 ± 0.69 days a week (Table 1).

Data were collected within a 30-day period. All horses had been put on the vibration plate prior to this study. Horses received treatments three days a week for 30-minute intervals. Horses received 15 total whole-body vibration treatments in the trial period from May 1st to May 29th. The plate was set to vibrate at 30-40 Hz for each treatment.

Baseline thermographic images were taken of the forelimbs and the thoracolumbar aspect of the back using the FLIR One Pro thermographic imaging camera. In the forelimb, images will be taken of the proximal aspect of the distal forelimb from the carpus to the toe of the hoof. In the back, images will be taken of the longissimus dorsi muscle, approximately from thoracic vertebrae 1-18 (Figure 4). Thermographic images will be taken from the knee to where the hoof meets the ground. Included software was used to store data. In order to avoid artifacts, horses were isolated in the barn for a minimum of 30 minutes after exposure to sunlight. This waiting period was based on a prior study which found that the minimum amount of time a horse has to be in the isolated room before artifacts are negligible is 30 minutes (Pavelski, 2015). Thermographic images were then taken immediately after treatment. Images of the same structures were taken for the control horses on each treatment day.

RESULTS

The Statistical Package for Social Sciences (SPSS) software, version 25, was used to analyze the data. The Shapiro-Wilk test of normality was run before proceeding with further tests. Normality of the data were confirmed. Statistical significance was determined by a p-value of $P<0.05$. A dependent T-test was performed to compare the changes within the test horses before and after treatment. When comparing the test horses' thermographic values from before and after treatment, there were significant differences in both the lower limb and the back with a significance level of $P<0.05$. Decreases in the mean surface temperatures for both the back and the lower limb values were noted after treatment. The mean difference between baseline and post-treatment lower limb values for the duration of the study was 3.8 ± 1.6 degrees Fahrenheit (Table 2, Figure 5). There was a two-tailed significance value of 0.000 (Table 2, Figure 5). The mean difference between baseline and post-treatment back values for the duration of the study was 3.3 ± 1.7 degrees Fahrenheit (Table 3, Figure 6) There was a two-tailed significance value of 0.000 (Table 3, Figure 6). An independent T-test was performed to compare the baseline measurements between the control and test horses over the trial Levene's Test for equal variances with a significance level of 0.05 (Sig > 0.05) allowed equal variances to be assumed. No statistically significant differences were noted between the control horses' measurements and the baseline measurements of the test horses over the course of the trial. There was a downward trend in temperature in the baseline measurements of the test horses for both the lower limb and the back (Figures 7, 8). Significant differences ($P < 0.05$) were seen by the end of the trial between test and control horses, with the test horses having decreased baseline values. An independent T-test was performed to compare the post treatment measurements to the measurements of the control horses over the trial period (SPSS Independent Samples Test). A significant difference ($P<0.05$) was discovered when comparing the lower limb values of post treatment measurements to the control horses' measurements throughout the duration of the trial with the control horses having higher temperature readings than the test horses (Figure 9). No significant differences were found in the back measurements.

DISCUSSION

This study found statistically significant differences between control and test horses following the treatment with whole-body vibration treatment. Performing the vibration treatment three days a week for 30 minutes sessions at 30-40 Hz produced significant changes in the test horses. When comparing the horses to themselves, there was a significant decrease in surface temperature after treatments in both the backs and the forelimbs of the test horses. This indicates that there is an immediate physiological change with the addition of the treatment. There was also a significant difference between the control horses' measurements and the post treatment forelimb measurements throughout the study, with the test horses having lower values. This could potentially indicate a long-term effect of treatment. Previous studies on the long-term effects of whole-body vibration have found potentially adverse effects as well as a chance of adaptation to the treatment (Halsberghe, 2017). More research is needed to determine if healthy horses have adverse effects to long term whole-body vibration therapy. The acute thermographic change has the potential to confirm claims that whole-body vibration has an effect on inflammation. Further research with other diagnostics is needed to confirm a certain correlation between whole-body vibration treatment and decreased inflammation. A trend was also noted with the lower limb baseline values of the test horses being consistently lower than the control horses, perhaps suggesting a long-term effect of decreasing surface temperature. There were no adverse side effects noted and all horses reacted well to treatment. Few changes were noted in the values for the longissimus dorsi. A previous study noted that performing whole-body vibration treatment for 30 min, twice daily, 5 days a week, for 60 days in addition to regular exercise significantly increased the size and symmetry of the multifidus muscle in the back (Halsberghe et al., 2016). Future research could potentially see if more frequent, and longer durations of treatment produce greater effects on large muscle groups.

Several limitations occurred throughout the course of this study. There was variation among the horses in terms of exercise and turnout time. While the workload for all horses was fairly similar the turnout time varied between 2-12 hours. Additionally, the ability to keep horses completely isolated from the elements was not feasible within the constraints of a working lesson barn. Horses were isolated in a similar location (a corner stall) for at least 30 minutes before any imaging occurred, however, they were not completely isolated from the elements. The stall still had a window that exposed the horses to limited amounts of sunlight.

The time requirement of this study led to additional constraints. Putting ten horses onto the plate for treatment, acquiring images for 20 horses and the required temperature isolation period made each trial day of the study approximately nine hours long. This allowed for ambient temperature to change throughout the treatment day. It is unclear if this had any effect.

Acquiring a larger sample size in future studies would potentially produce results indicating different effects of whole-body vibration treatment. Considering the trend that noted the baselines of the test horses becoming lower throughout the trial, a study with prolonged treatment may indicate positive long-term effects in managing musculoskeletal inflammation. Additionally, since there was a significant difference between the control horses and the test horses post treatment lower limb values, it would be interesting to try different parameters in order to potentially observe differences in the back values. Possible changes would include different settings of the vibration (either higher or lower Hertz), duration or frequency. A 2013 study examining whole-body vibration and blood markers discovered that acute, low frequency vibration treatments produced a decreased serum cortisol level, whereas moderate to high intensity vibration treatments caused an increase in serum cortisol levels (Carstanjen et al., 2013). This suggests that there may be a correlation between stress levels and whole-body vibration therapy. Further research could also model this study but examine blood markers for inflammation rather than endocrine levels. Additionally, it displays clear differences between high and low frequency treatments, more research is needed to determine what other impacts the different frequency treatments may have.

There are several different whole-body vibration plates currently marketed and the efficacy of the different products could be compared. If differences were noted, it could help owners, practitioners and barn owners pick the correct model for the problem they are trying to correct. Different diagnostic procedures could also be implemented by potentially looking for inflammatory blood markers or salivary proteins before and after treatment.

Whole-body vibration as a therapeutic modality for horses still requires much research. At the Otterbein facility, it is commonly noted to produce positive anecdotal effects. The effects are well noted in human medicine, but as with many other complementary veterinary therapies, there are still unknowns. Further research in whole-body vibration treatment is needed to determine the best duration, strength and frequency for addressing musculoskeletal inflammation in the horse. Additional uses of thermography as a diagnostic are required to determine its effectiveness at diagnosing inflammation in horses. Future research that couples thermography with a veterinary diagnostic such as ultrasonography may help to confirm or deny its efficacy as a diagnostic tool.

FIGURES & TABLES

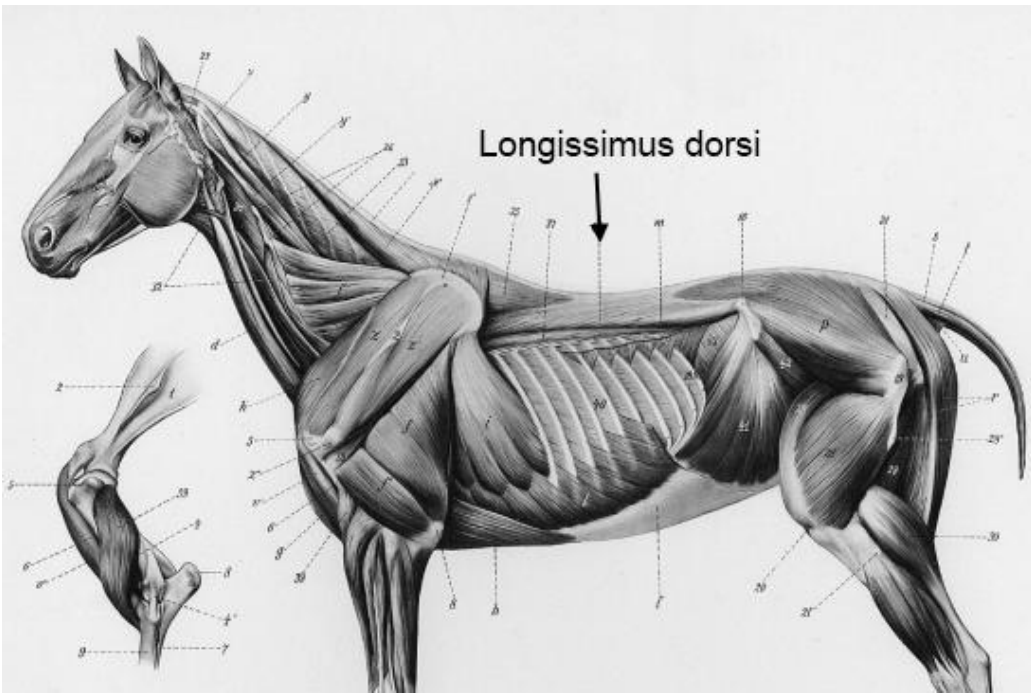

Figure 1. An image displaying the location of the longissimus dorsi muscle of the equine back (Nikkel & Nikkel 2012)

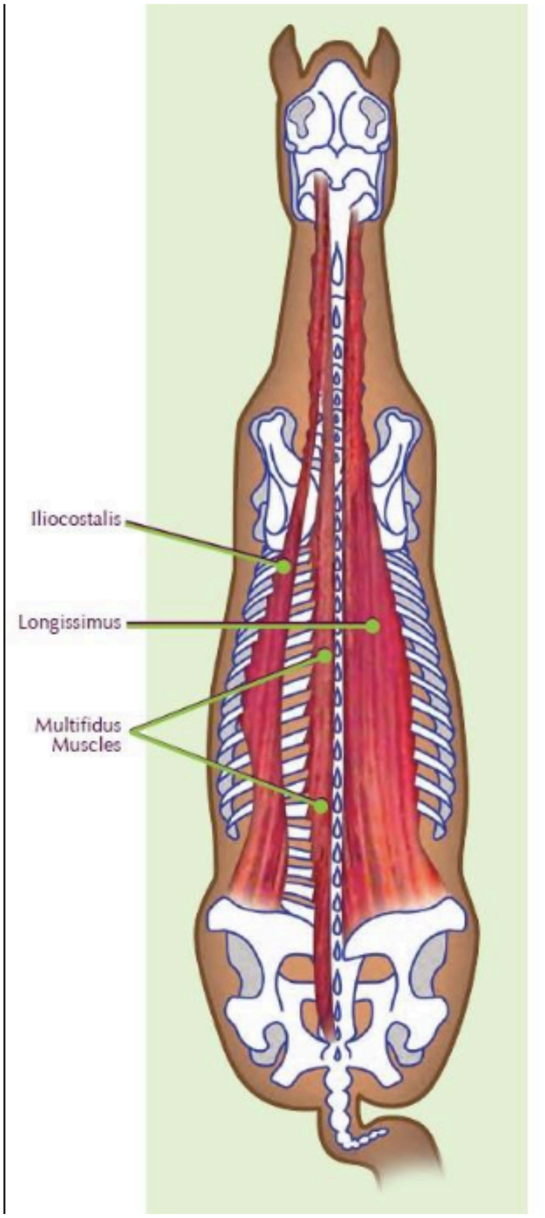

Figure 2. Illustration showing the epaxial muscles of the equine back (Horsejournals.com, 2020)

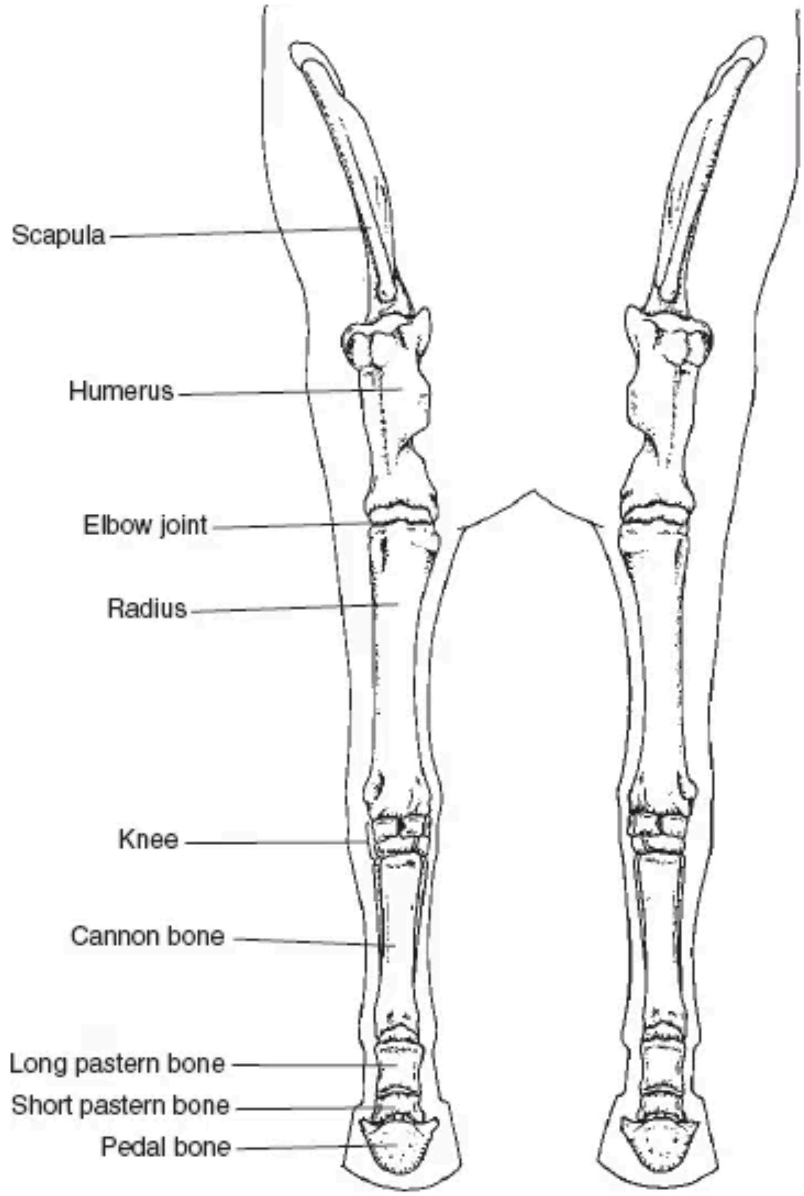

Figure 3. Diagrams of the dorsal and plantar aspects of the equine forelimb(The Veterinarian Key, 2017)

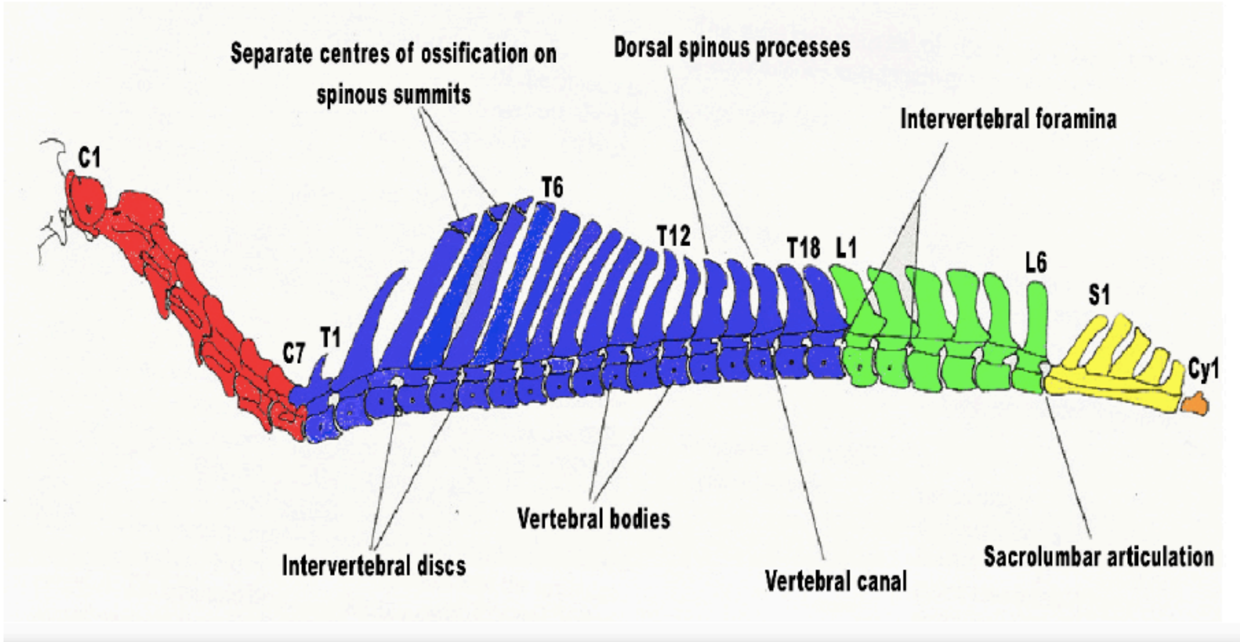

Figure 4. Diagram of the equine vertebral column. Cervical vertebrae (C, red); thoracic vertebrae (T, blue), lumbar vertebrae (L, green), sacral vertebrae (S, yellow) and coccygeal vertebrae (CY, orange) (modified from Jeffcott and Dalin, 1980)

Horse	Average Time Ridden (minutes)	Average Days Ridden per Week
1	40	0.6
2	30	0.6
3	36.7	0.6
4	36	1
5	30	0.2
6	46.4	1.4
7	36.7	0.6
8	30	0.4
9	43.3	1.2
10	40	0.2
11	28.3	1.2
12	38.3	1.8
13	43	2
14	42.1	1.4
15	0	0
16	28.3	2
17	0	0
18	15	0.4
19	40	2
20	0	0
Average	30.2 ± 14.17	0.88 ± 0.69

Table 1. Table displaying the average ride duration and frequency during study.

Paired Samples Test
Paired Differences

Limb Pre-Mean vs. Limb Post-Mean	Mean	Std. dev	Std. Error Mean	t	df	Sig. (2-tailed)
	3.83	1.61	0.508	7.54	9	0.000

Table 2. Quantitative data comparing the test horses' mean baseline and post treatment surface temperatures for the lower limb.

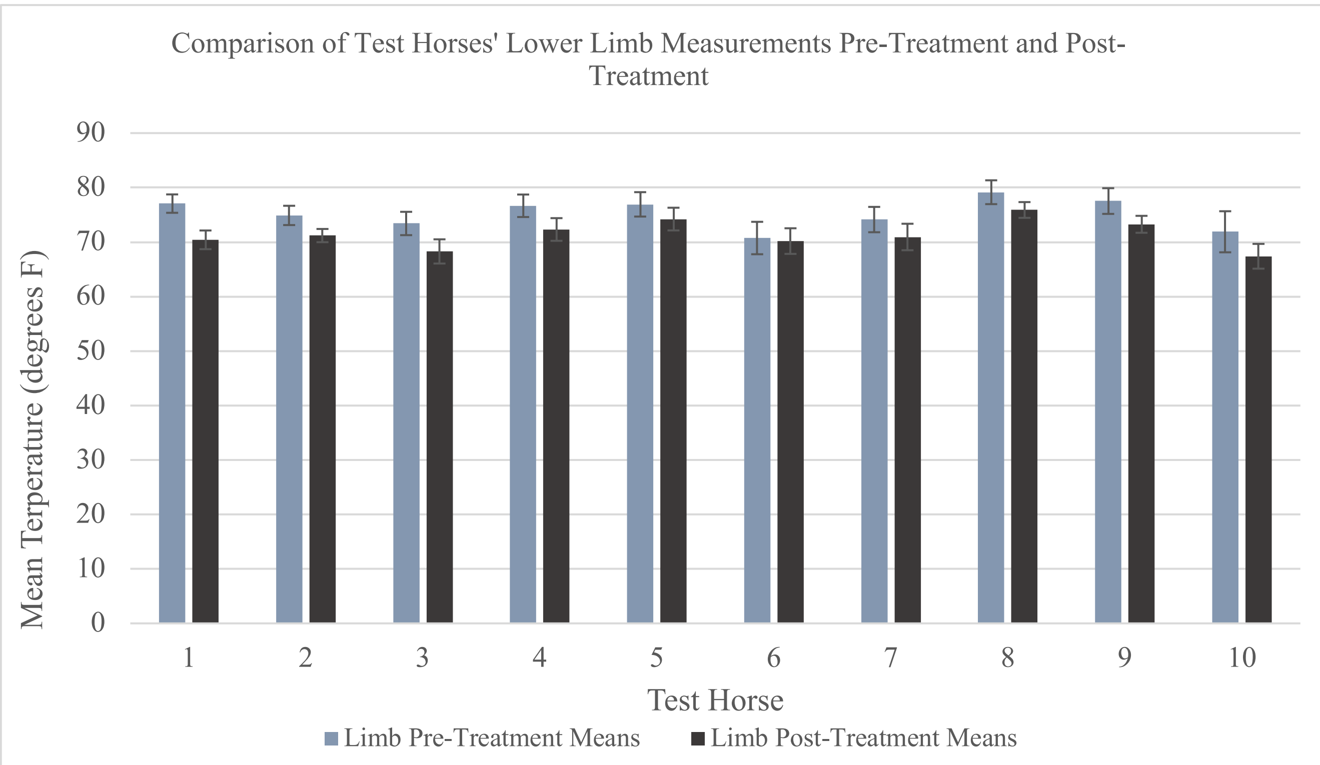

Figure 5. Comparison of the mean surface temperature measurements of the lower limb before and after treatment of test horses. Error bars displaying standard error.

Paired Samples Test
Paired Differences

Back Pre-Mean vs. Back Post-Mean	Mean	Std. dev	Std. Error Mean	t	df	Sig. (2-tailed)
	3.33	1.74	0.549	6.07	9	0.000

Table 3. Quantitative data comparing the test horses' mean baseline and post treatment surface temperatures for the back.

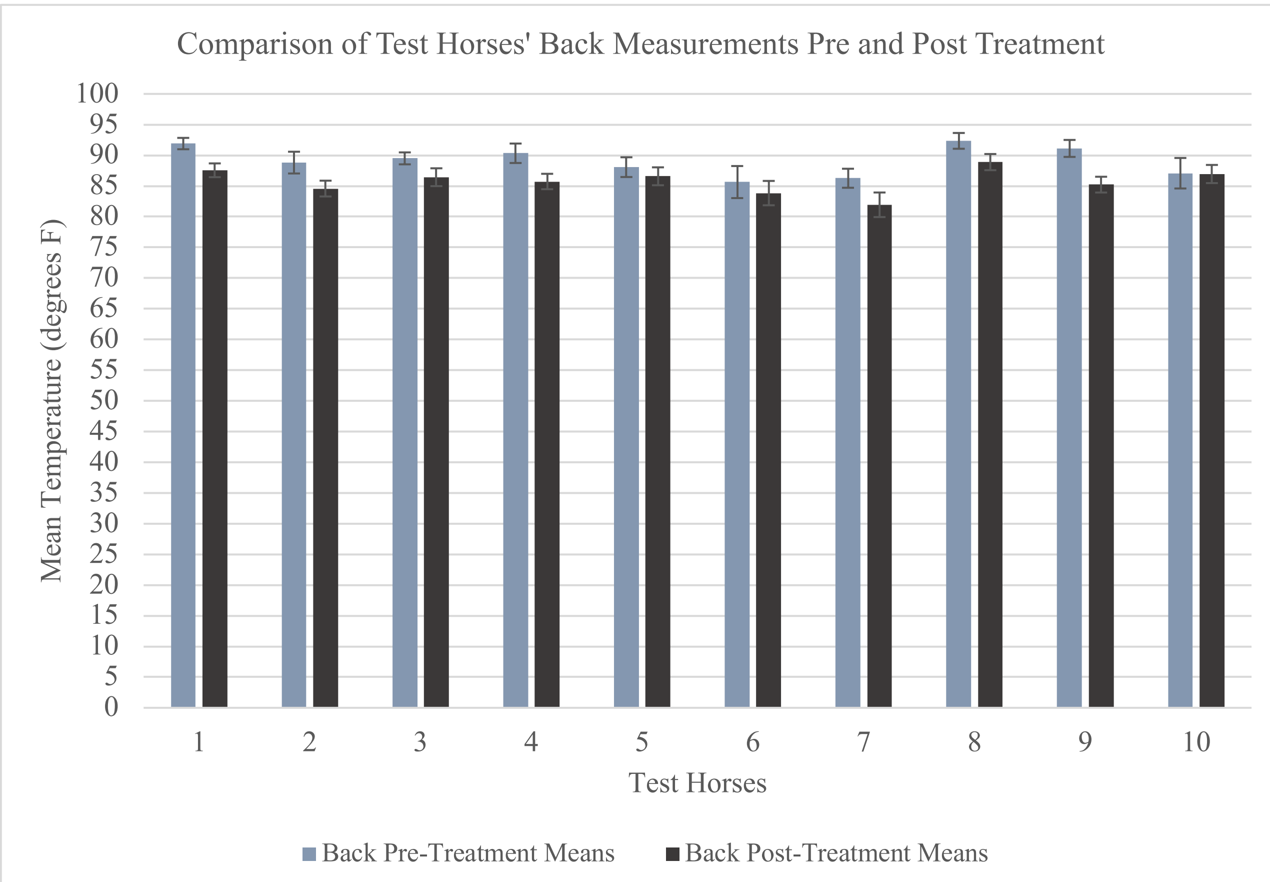

Figure 6. Comparison of the mean surface temperature measurements of the back before and after treatment of test horses. Error bars displaying standard error.

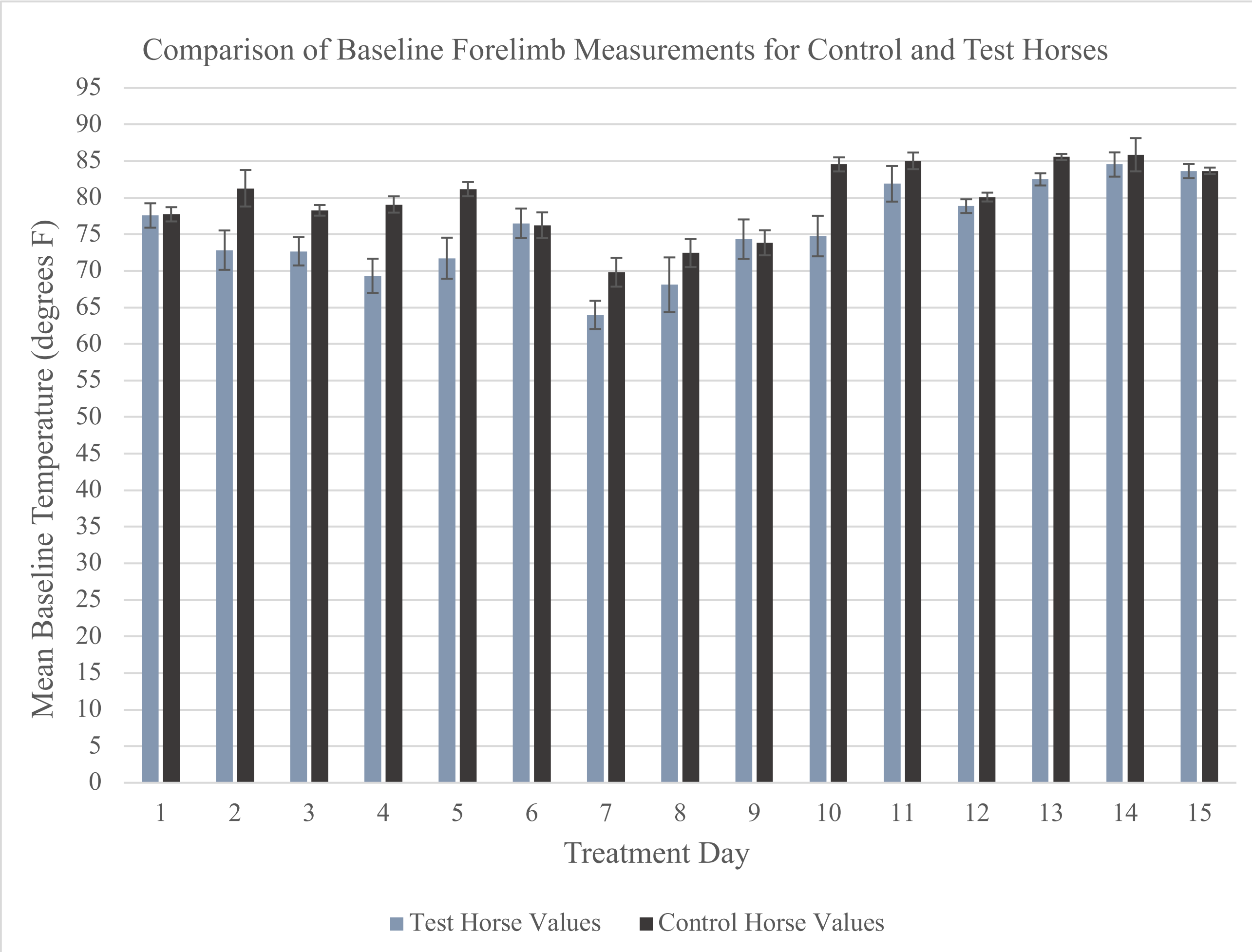

Figure 7. The differences between the baseline measurements of the forelimb in test and control horses over time. Error bars displaying standard error.

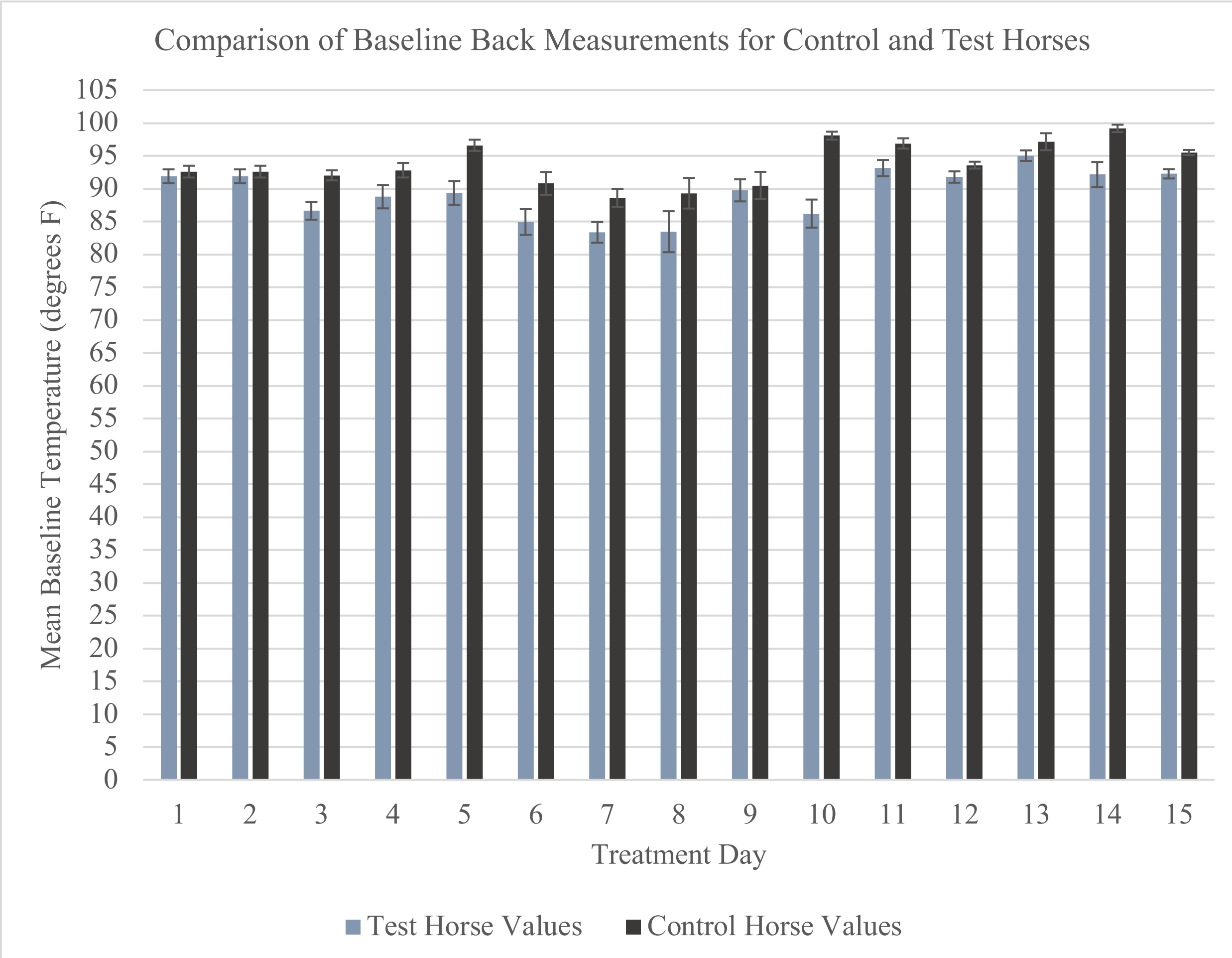

Figure 8. The differences between the baseline measurements of the back in test and control horses over time. Error bars displaying standard error.

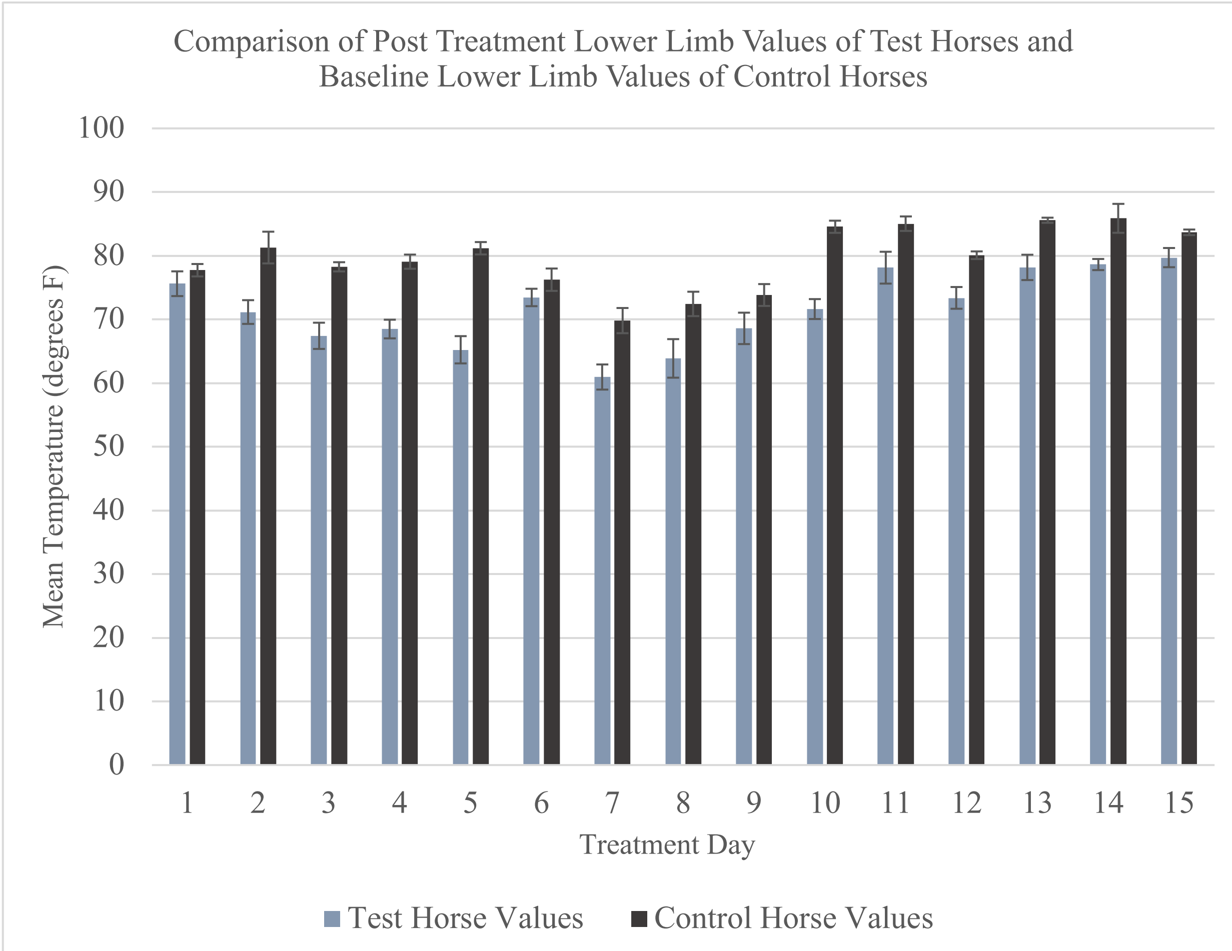

Figure 9. Comparison of the baseline measurements of control horses with the post treatment measurements of test horses. Error bars displaying standard error.

REFERENCES

Adams, S. B. (n.d.). Overview of Lameness in Horses - Musculoskeletal System. Retrieved from https://www.merckvetmanual.com/musculoskeletal-system/lameness-in-horses/overview-of-lameness-in-horses

Adams, S. B. (n.d.). Overview of Musculoskeletal System - Musculoskeletal System. Retrieved from https://www.merckvetmanual.com/musculoskeletal-system/musculoskeletal-system-introduction/overview-of-musculoskeletal-system

Gatt, A., Formosa, C., Cassar, K., Camilleri, K. P., De Raffaele, C., Mizzi, A., Azzopardi, C., Mizzi, S., Falzon, O., Cristina, S., & Chockalingam, N. (2015). Thermographic patterns of the upper and lower limbs: baseline data. *International journal of vascular medicine*, *2015*, 831369. https://doi.org/10.1155/2015/831369

Buchner, H. H. F., Peham, C., Perrier, J., Zimmer, L., & Haase, L. (2017). Effects of whole body vibration on the horse: Actual vibration, muscle activity, and warm-up effect. *Journal of Equine Veterinary Science, 51*, 54-60.

Carstanjen, B., Balali, M, Gajewski, Z., Furmańczyk, K., Bondzio, A, Remy, B. & Hartmann, H. (2013). Short-term whole-body vibration exercise in adult healthy horses. *Polish Journal of Veterinary Sciences.* 16. 403-5. 10.2478/pjvs-2013-0057.

Cardinale M, Wakeling J (2005). Whole body vibration exercise: are vibrations good for you? *British Journal of Sports Medicine.* 2005;39:585-589.

Cetinkaya, M.A. & Demirutku, A. (2012). Thermography in the assessment of equine lameness. *Turkish Journal of Veterinary Animal Science*. 36, 43–48.

Chojnowski M. (2017). Infrared thermal imaging in connective tissue diseases. *Reumatologia*, *55*(1), 38–43. https://doi.org/10.5114/reum.2017.66686

Cottriall, S., Ritruechai, P., & Wakeling, J. (2008). The effects of training aids on the longissimus dorsi in the equine back. *Comparative Exercise Physiology, 5*(3-4), 111-114. doi:10.1017/S1478061509342346

De Cocq, P., Van Weeren, P.R. and Back, W. (2004), Effects of girth, saddle and weight on movements of the horse. *Equine Veterinary Journal*, 36: 758-763. doi:10.2746/0425164044848000

Duberstein, K. J. (2012). Evaluating Horse Conformation. Retrieved from UGA Extension: http://extension.uga.edu/

Equivibe.com. (2019, April 25). Retrieved from https://equivibe.com/faq/

Halsberghe, B. T. (2017). Long-term and immediate effects of whole-body vibration on chronic lameness in the horse: A pilot study. *Journal of Equine Veterinary Science, 48*(1), 121-128.e2.

Halsberghe, B., Gordon-Ross, P. & Peterson, R.. (2016). Whole body vibration affects the cross-sectional area and symmetry of the m. multifidus of the thoracolumbar spine in the horse. *Equine Veterinary Education*. 29. 10.1111/eve.12630.

Harman, J.C. (1999) Tack and saddle fit. *Veterinary Clinics of North America: Equine Practice.* 15, 247-261.

Understanding Equine Back Pain. (2020, February 21). Retrieved from https://www.horsejournals.com/horse-care/illness-injury/prevention/understanding-equine-back-pain?fbclid=IwAR2X5koeBrb2aGtGuDnsslCNDqIJivIozmDGUES-uQYdWnhzP1uf7LVnzRk

Jeffcott, L. B., & Dalin, G. (1980). Natural rigidity of the horse's backbone. *Equine Veterinary Journal*, *12*(3), 101–108. doi: 10.1111/j.2042-3306.1980.tb03393.x

Mincham, C. (2016). Retrieved from https://teara.govt.nz/en/equestrianism-and-horse-Sports

Nikkel, R., & Nikkel, D. (2012, September 7). Retrieved from https://www.rodnikkel.com/content/saddle-tree-blog-from-shop-and-desk/the-longissimus-dorsi/

Pavelski, M., da, S. B., Busato, E., & Dornbusch, P. T. (2015). Infrared thermography evaluation from the back region of healthy horses in controlled temperature room. *Ciência Rural, 45*(7), 1274-1279.

Ritruechai, P., Weller, R., & Wakeling, J. M. (2008). Regionalization of the muscle fascicle architecture in the equine longissimus dorsi muscle. *Equine Veterinary Journal, 40*(3), 246-251. doi:10.2746/042516408x273675

Simão AP, Avelar NC, Tossige-Gomes R, et al. (2012) Functional performance and inflammatory cytokines after squat exercises and whole-body vibration in elderly individuals with knee osteoarthritis. *Archives of Physical Medicine and Rehabilitation*. 2012;93(10):1692–1700. doi:10.1016/j.apmr.2012.04.017

Soroko, M., and Kevin H.. (2018). Infrared Thermography: Current Applications in Equine Medicine. *Journal of Equine Veterinary Science*, vol. 60, 2018, doi:10.1016/j.jevs.2016.11.002.

Sumano H., Hoyas ML., Brumbaugh GW. (1999). Pharmacologic and alternative therapies for the horse with chronic laminitis. *Veterinary Clinics of North America: Equine Practice.* 1999;15(2):495–viii. doi:10.1016/s0749-0739(17)30157-8

The forelimb. (2017). Retrieved from https://veteriankey.com/the-forelimb/

Thorpe, C.T. Extracellular Matrix Synthesis and Degradation in Functionally Distinct Tendons; University College London: London, UK, 2010.

Thorpe, C. T., Udeze, C. P., Birch, H. L., Clegg, P. D., & Screen, H. R. (2013). Capacity for sliding between tendon fascicles decreases with ageing in injury prone equine tendons: a possible mechanism for age-related tendinopathy?. *European cells & materials*, *25*, 48–60. https://doi.org/10.22203/ecm.v025a04
.

Wakeling, J., Barnett, K., Price, S. & Nankervis, K. (2006). Effects of manipulative therapy on the longissimus dorsi in the equine back. *Equine and Comparative Exercise Physiology*. 3. 10.1017/ECP200693.

APENDIX

Appendix 1. Mean values of test horses for lower limb and back measurements before and after treatment

	Lower Limb Mean Baseline Values (degrees F)	Lower Limb Post Treatment Mean Values (degrees F)	Back Mean Baseline Values (degrees F)	Back Post Treatment Mean Values (degrees F)
Test 1	77.06 ± 6.3	70.41 ± 6.65	91.9 ± 3.46	87.56 ± 4.49
Test 2	74.89 ± 6.62	71.1 ± 4.70	88.81 ± 6.63	84.5 ± 5.15
Test 3	73.41 ± 8.01	68.28 ± 8.61	89.50 ± 3.64	86.43 ± 5.82
Test 4	76.66 ± 7.73	72.31 ± 8.06	90.33 ± 5.93	85.73 ± 5.02
Test 5	76.92 ± 8.38	74.24 8.06	88.07 ± 6.02	86.58 ± 5.84
Test 6	70.74 ± 11.14	70.18 ± 9.11	85.64 ± 9.77	83.84 ± 7.94
Test 7	74.13 ± 8.70	70.93 ± 9.41	86.26 ± 5.80	81.94 ± 8.00
Test 8	79.15 ± 8.18	75.89 ± 5.61	92.35 ± 4.81	88.89 ± 5.27
Test 9	77.53 ± 8.83	73.26 ± 6.02	91.12 ± 5.17	85.22 ± 5.14
Test 10	71.8 ± 8.43	67.39 ± 5.09	87.08 ± 5.55	86.95 ± 3.62
Control 1	80.89 ± 5.91	n.a.	93.81 ± 3.47	n.a.
Control 2	78.44 ± 5.60	n.a.	92.06 ± 4.29	n.a.
Control 3	78.83 ± 8.08	n.a.	93.12 ± 5.65	n.a.
Control 4	80.41 ± 4.33	n.a.	95.17 ± 2.85	n.a.
Control 5	79.63 ± 4.72	n.a.	95.38 ± 3.70	n.a.
Control 6	78.84 ± 9.85	n.a.	92.52 ± 7.59	n.a.
Control 7	78.99 ± 7.99	n.a.	92.45 ± 5.62	n.a.

Control 8	80.76 ± 4.70	n.a.	95.46 ± 4.27	n.a.
Control 9	80.42 ± 5.84	n.a.	94.41 ± 3.86	n.a.
Control 10	79.19 ± 4.99	n.a.	94.65 ± 3.86	n.a.