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Clinical Studies

Front Hoof Thermographic Imaging Change After Electro-acupuncture in Performance Horses

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ABSTRACT

The present study investigated whether electro-acupuncture (EAP) can improve front hoof thermal asymmetry in horses as detected by front hoof thermography imaging. Thirty-five client-owned horses that presented for traditional Chinese veterinary medicine (TCVM) exam and treatment for poor performance were enrolled in the study. After 20 minutes of stall rest, bilateral front hoof thermography (pre-EAP) was performed in a designated stall. This was followed by the TCVM exam and 30 minutes of EAP treatment. Immediately afterwards, bilateral front hoof thermography (post-EAP treatment) was repeated. From each thermal image, the mean temperature of the dorsal hoof surface was calculated. Horses were categorized into two groups based on the pre-EAP hoof temperature difference between the front hooves. Horses with a temperature difference greater than 1 °F between the front feet were placed in Group A; otherwise in Group B. The data showed that Group A (n=14) had a mean between-hoof temperature difference that changed/reduced significantly (p=0.029) after EAP treatment when compared to pre-EAP. In Group B (n=21), the changes were not significant (p=0.848). Furthermore, the mean temperature change in Group A was significantly greater than that in Group B (p=0.006). Study findings demonstrated that EAP treatment facilitates return of symmetric front hoof surface thermal distribution in horses with asymmetric thermal distribution greater than 1 °F temperature difference between front hooves.

Keywords: equine electro-acupuncture, hoof thermography, performance horses

ABBREVIATIONS: EAP: electro-acupuncture; IRT: infrared thermography; ROI: region of interest; TCVM: traditional Chinese veterinary medicine

Lameness due to foot pain is a common reason for horse keepers to seek veterinary care. Foot pain has a number of origins, from simple disorders (e.g. bruise, thrush) to other common hoof disorders such as hoof wall cracks, abscesses and white line disease. More critical concerns, such as laminitis, is one of the most common causes of poor performance in horses and has been reported to affect all limbs; although it's most common in the forelimbs.[1-4]

Diagnosis and treatment of foot pain is always challenging. Outside the conventional treatments, studies have demonstrated that acupuncture can be an effective hoof disorder treatment. Electro-acupuncture (EAP) with its stronger acupoint stimulation compared to other acupuncture techniques, is generally considered to be more effective in the treatment of hoof pain.[5-8] Despite a growing body of literature supporting the use of acupuncture in equids, the mechanism of action or even how the treatment alters a certain physiologic condition in horses is still poorly understood.[6,8]

Thermography is an imaging technique that uses an infrared camera to map and measure body surface temperature of specific anatomic sites. Skin temperature is largely under the control of the autonomic nervous system and inflammatory processes. When healthy, sagittal symmetry of thermal distribution is expected throughout the body. Asymmetric infrared emission can be indicative of inflammation, sympathetic nervous system dysfunction or other pathology. The use of infrared thermography (IRT) as a noninvasive method to detect local thermal changes continues to increase, along with refined protocols to minimize artifacts. Several studies (in humans and dogs) have investigated the effects of acupuncture treatment on body surface temperature through IRT.[9-11] Thermography has especially been used successfully to aid in diagnosis and monitoring lameness (e.g. carpal/tarsal joint effusion, flexor tendonitis) and back pain in horses.[12-16] Thermographic evidence for the effectiveness of acupuncture in equine neuromuscular disease was reported in 1998. The study demonstrated that acupuncture often corrects abnormal vasomotor tone within 0.5 to 3.5 hours of needling, usually resolving vasoconstriction affecting large dermatomes.[17] Similar thermography studies on EAP treatment of the hoof, however, have not been reported in the literature.

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Hoof inflammation is often associated with regional blood circulation changes that can lead to surface thermal changes, similar to other tissues. This should allow the sensitive modern thermal camera to detect pathology in the hoof associated with temperature change, possibly before clinical signs appear. The purpose of this study was to determine the effect of EAP treatment on hoof temperature measured by thermographic imaging. It was proposed that if EAP can reduce hoof inflammation in horses, there is likely a temperature change associated with the effect, which would be detectable by thermal imaging. The current study tested the hypothesis that EAP treatment results in greater changes in horses with asymmetric thermal imaging between front hooves than those with more balanced thermal imaging of the front feet.

MATERIALS AND METHODS

Animals

Horses older than 1 year, regardless of sex or breed admitted to the Equine Acupuncture Center (University of Florida & Chi University), Reddick, Florida, USA between Septemer15th, 2019 and December 15th, 2020, for traditional Chinese veterinary medicine (TCVM) exam and treatment for poor performance issues were eligible for the study. No breakdown or further analysis for the cause of the poor performance, was performed for this study. Horses were only excluded from recruitment if informed verbal consent was not obtained from the owner. Rectal temperatures of all study candidates were measured after 20 minutes of stall rest and any horse recording over 101 °F or having medications or wraps on the hoof that could not be removed were excluded, as these conditions were likely to affect the thermography measurements.

Experimental Procedure

Front Hoof Thermography

After obtaining permission for study participation, each recruited horse was individually brought to the designated imaging stall. The front hooves were then visually inspected for problems (e.g. wraps, topical hoof medications) and a potential study horse was excluded from sampling if there was any other factor determined to interfere with accurate hoof thermal imaging. The horse was then allowed to rest, loose in the stall, for at least 20 minutes to acclimatize to the thermographic imaging environment.[15] This was followed by checking the rectal temperature of a horse to verify a body temperature less than 101 °F (normal equine range: 36.0 °C to 38.0 °C or 96.8 °F to 100.4 °F).[16]

Hoof imaging for all study horses was then performed with a portable high-resolution infrared camera[a] (Table 1). The camera used in the study investigation was calibrated by a company representative with expertise in the equipment prior to its use. The experimental protocol for all procedures in the study (equipment, environment, imaging technique, image analysis) were performed in a standardized manner as described in a previous pilot study.[16]

Thermal images were taken in the designated IRT imaging stall by the same experienced imaging person (SD). Study horses were acclimatized to the stall, which had a cement floor covered by a rubber mat and very thin layer of fine shavings. The ambient temperature ranged between 68 °F and 86 °F (i.e. 20 °C and 30 °C), which is consistent with veterinary guidelines for infrared thermography.[12] The IRT imaging techniques were identical to a previous pilot study, with the region of interest (ROI) set as a dorsopalmar view of the front hooves.[9] The front foot was placed on a wood board when the hoof images were taken. To reduce artifacts from background, a cardboard screen was used to block the rear legs of the horse and other objects in the stall (Figure 1).

The images were first captured with grey scale to allow accurate focusing and then changed to the rainbow palette for analysis. Freehand drawing on the recorded images was used to select the targeted area of the hoof for data collection. The hand drawn region included the hoof above the shoe nails and below the upper coronary band hair margin (Figure 2). It was established in a pilot study that freehand drawing of ROI was better than the IRT camera preset frame, as shoe nails and coronary band hair captured in the preset frame created artifacts.[9] This method also allowed horses to be shod or unshod as the thermal calculated zone did not include the shoe nail region. The thermal reading of this hoof region was collected for analysis in an identical manner in all study horses to avoid bias.[9,10]

Table 1: Summary of specifications for the thermal camera[a] used to produce hoof images of study horses; the unit measured 327,680 points of temperature (highest resolution available)

Thermal Camera Specifications	
Detector Array	FPA (VOx)
Pixel Resolution	640×512
Frame Rate	30 Hz
Pixel Pitch	17 µm
Thermal Sensitivity	<0.036 °F at 86 °F
Accuracy	+/- 1.8 °F
Spectral Response	7 µm-14 µm. 75G Shock/4G vibration

Figure 1: The front foot was placed on a wooden board (B) and cardboard (A) was placed to block the rear legs for thermal imaging.

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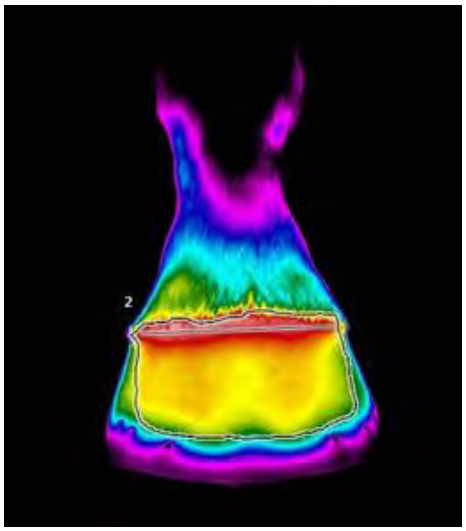

Figure 2: This thermographic image illustrates the hand drawn region of interest used for thermal data. The hand drawn region included the hoof above the shoe nails and a straight line was drawn to indicate the widest or middle line of coronary band.

Electro-acupuncture (EAP) Treatment

All horses were examined for poor performance after the thermography procedure. They received a TCVM pattern diagnosis that included an acupoint sensitivity scan to determine the appropriate acupuncture points to relieve pain for each individual horse.[9] Although acupoints used in EAP might be different among study horses, the goal was the same, which was to promote *Qi* and Blood circulation to relieve local *Qi* blockage (the cause of pain in TCVM). All enrolled horses received EAP treatment (continuous stimulation, 30 hertz, 30 minutes) prescribed by the same clinician (HX), who was blinded to the thermography findings. The same EAP machine (acupunctoscope)[b] was used for all study horses. The intensity of stimulation for each horse was different, but with the same clinical tolerance level; horses demonstrated awareness of the stimulation but exhibited tolerance of the intensity with no obvious discomfort.

Data Analysis

The thermal data for each horse was extracted from the thermal images taken on each front hoof, before (pre-) and after (post-) EAP treatment. From each thermal image, the mean temperature of the dorsal surface of the front hoof was calculated. Horses were categorized into two groups based on the pre-EAP between-hoof temperature difference. Horses with greater than 1 °F temperature difference between the left and right front hooves were in Group A; otherwise in Group B.

Summary statistics of the pre-EAP and post-EAP front hoof temperature difference data and their change were presented as mean±SD. Statistical significance of hoof temperature changes (pre- to post-EAP) within each group was evaluated using the Wilcoxon signed rank test, whereas the between group differences (Group A vs. Group B) for temperature changes was determined by the Wilcoxon rank sum test. Significance level was set at 0.05 for all tests. All data graphic presentations and statistical analysis were performed using the widely used statistical software R[c].

RESULTS

There were 41 horses presented for poor performance during the study enrollment period. After clinical examination, 35 horses qualified for EAP treatment based on their examination at presentation and owner consent. The 35 horses enrolled in the study contained 24 geldings and 11 mares. The study data was collected over a 1-year period. The age of horses ranged from 4-28 years, with an average of 9.7 years. There were 17 Quarter horses, 5 Thoroughbreds, 4 Hanoverians, 2 Paint horses, 2 Warmbloods, and one of each breed from Trakehner, Percheron, Rhinelander, Pony and Selle Francais.

Based on the aforementioned pre-EAP hoof temperature criterion, Group A had 14 horses and Group B had 21. The distributions of sex were not significantly different between groups (mare proportion A: 4/14=28.6% vs. B: 7/21=33.3%; p=1.000). On the breed, both groups consisted of multiple breeds (7 in A and 8 in B), with Quarter horses as the most common breed in either group. When comparing the proportion of Quarter horses, the difference was not significantly different between the two groups (A: 7/14=50% vs. B: 9/21=42.9%; p=0.739).

In Group A, the mean±SD pre-EAP hoof temperature difference was 1.86±0.77 °F and reduced to 1.11±1.17 °F after EAP treatment; the change was statistically significant (p=0.029, Table 2, Figure 3). Group B had a mean±SD front hoof temperature difference of 0.34±0.32 °F which increased to 0.59±0.66 °F; the change was not statistically significant (p=0.848, Table 2, Figure 3). In addition, the hoof temperature change in Group A was significantly greater than that in Group B (p=0.006, Table 3, Figure 4).

Table 2: Mean front hoof temperature difference of pre- and post-EAP measurements

	Pre-EAP Temperature Difference (mean±SD), °F	Post-EAP Temperature Difference (mean±SD), °F	*p*-value (pre-AP>post-AP)
Group A	1.86±0.77	1.11±1.17	0.029
Group B	0.34±0.32	0.59±0.66	0.848

Table 3: Mean front hoof temperature change between pre- and post-EAP measurements

	Mean Change of Between-hoof Temperature Difference (mean±SD), °F
Group A	0.76±1.35
Group B	-0.25±0.75
A vs. B	0.006

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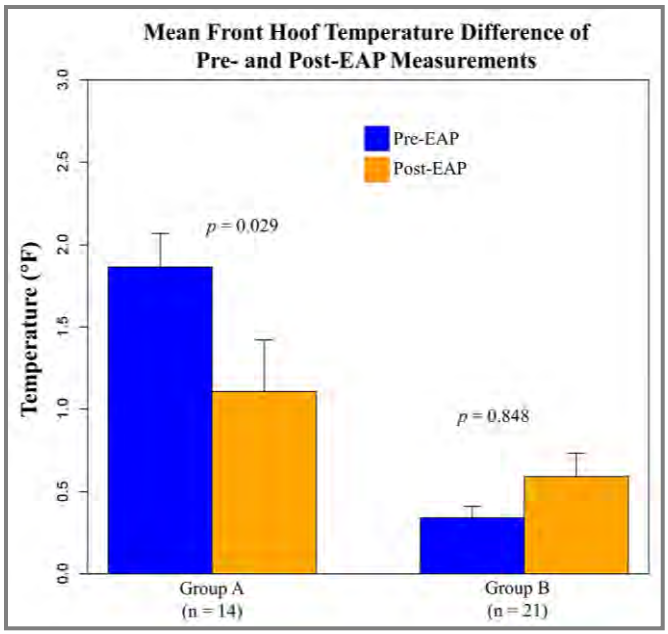

Figure 3: Mean front hoof temperature difference of pre- and post-EAP measurements

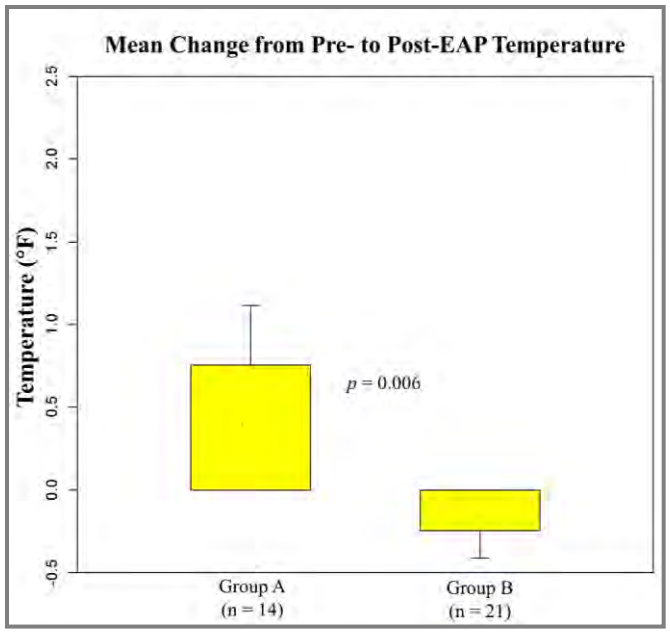

Figure 4: The mean hoof temperature change in Group A and Group B

DISCUSSION

Thermography is an imaging technique that uses an infrared camera to map and measure body surface temperature of specific anatomic sites such as the equine hoof. The present study investigated whether electro-acupuncture affects front hoof temperature, as detected by a thermal imaging camera. The present study compared EAP treatment effect on horses with greater than 1 °F front hoof temperature difference to horses with no significant temperature difference between their front hooves. Study findings demonstrated that 30 minutes of patient-appropriate EAP treatment significantly reduced (p=0.029) front hoof temperature difference in horses with asymmetric front hoof temperatures, whereas the treatment had little effect on the horses with normal (balanced) between-hoof temperature difference. The results supported the study hypothesis that EAP treatment can affect hoof temperature as measured by IRT.

Several studies have investigated the effects of acupuncture treatment on body surface temperature through IRT. In a human study, Cai et al. performed 30-minute dry-needle acupuncture on bilateral aural regions in 54 patients with tinnitus. It was found that the temperature differential (i.e. maximum and minimum temperatures) within either the affected or contralateral side reduced significantly after the treatment; however, the study did not evaluate how acupuncture affected the thermal difference between the two sides.[11] Um et al. randomly assigned 8 dogs with induced arthritis into acupuncture treated and non-treated groups. Using IRT, their findings noted the between-stifle temperature difference in the treated group returned to normal range (<0.3 °C), whereas the difference remained high in the non-treated group (p<0.05 between groups).[18] Um's results are similar to the present study in terms of outcome measurement; however, the control groups are different. A more recent report (randomized, controlled, blinded study) used IRT to investigate the effects of acupuncture treatment of back pain in dogs.[19] The study found that the treated group's mean temperature change (pre through post-treatment) was significantly greater than the no-treatment control group (p<0.001). These and the current study indicate that thermography can be a useful tool to evaluate the physiologic effects of acupuncture treatment in patients with musculoskeletal diseases, regardless of the species.

The regulation of body function by acupuncture as well as mechanisms of action have been studied extensively. One of the most interesting features of acupuncture is its ability to bidirectionally regulate the body's homeostatic values either in hyper- or hypofunctional states. This has been confirmed by biomedical researchers in China over the past decades and has also been observed by their peers internationally.[20] In a similar fashion, this study demonstrated acupuncture's bi-directional effect on maintaining/enhancing body homeostasis with return of asymmetric front hoof temperatures in Group A toward normal temperature symmetry.

A limitation of this study is the short period used for IRT re-evaluation of hoof temperature after EAP treatment (i.e. 30 minutes). It would be interesting to study longer-term effects on thermal readings of the hooves (e.g. 4 hours, 1 day and 1 week) after the EAP treatment. In future research, investigations on correlation between thermal imaging and lameness, with and without acupuncture treatment, would increase clinical relevance.

In summary, this study used thermographic imaging to investigate the effect of EAP treatment on horses with

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poor performance by comparing individuals with asymmetric front hoof thermal distribution to those with symmetric front hoof thermal distribution. Study findings demonstrated EAP treatment significantly reduced hoof temperature difference in the group with front hoof asymmetric thermal distribution but had little effect on those with symmetric thermal distribution. These findings indicate the effectiveness of a 30-minute EAP treatment on normalizing hoof temperature and suggest that thermographic imaging can provide a diagnostic system to monitor the effect of treatments such as electro-acupuncture.

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Declaration of Interest and Funding

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of this paper and the authors did not receive any specific grant of funding from any organization in the public, commercial or non-profit sectors.

FOOTNOTES

[a] Digatherm's IR Tablet 640 thermal camera, Digatherm LLC, Ocala, FL, USA

[b] Electro-acupuncture stimulator (JM-3A 电针仪), Wuxi Jiajian Medical Instrument Co., Ltd, Wuxi, China

[c] R version 4.2.1. The R Foundation for Statistical Computing Vienna Austria; http://www.R-project.org

REFERENCES

1. Collins S, Pollitt C, Wylie C et al. Laminitic pain: Parallels with pain states in humans and other species. Vet Clin North Am Equine Pract 2010; 26(3):643-671. https://doi.org/10.1016/j.cveq.2010.08.001
2. Ireland J, Wylie C, Collins S et al. Preventive health care and owner-reported disease prevalence of horses and ponies in Great Britain. Res Vet Sci 2013; 95(2):418-424. https://doi.org/10.1016/j.rvsc.2013.05.007
3. Shin S, Kim S, Lioyd S et al. Prevalence of hoof disorders in horses in South Korea. The Open Agriculture Journal 2020; 14:25-29. https://doi.org/10.2174/1874331502014010025
4. Holzhauer M, Bremer R, Santman-Berends I et al. Cross-sectional study of the prevalence of and risk factors for hoof disorders in horses in The Netherlands. Prev Vet Med 2017; 140:53-59. https://doi.org/10.1016/j.prevetmed.2017.02.013
5. Xie H, Ott E, Colahan P. The effectiveness of electro-acupuncture on experimental lameness in horses. Am J Trad Chin Vet Med 2009; 4(2):17-29. https://doi.org/10.59565/001c.126051
6. Shmalberg J, Xie H. The clinical application of equine acupuncture. J Equine Vet Sci 2009; 29(8):645-652. https://doi.org/10.1016/j.jevs.2009.07.010
7. Faramarzi B, Lee D, May K et al. Response to acupuncture treatment in horses with chronic laminitis. Can Vet J 2017; 58(8):823-827.
8. Repac J, Mangan E, Xie H. Clinical application of acupuncture in equine practice. Vet Clin North Am Equine Pract 2022; 38(3):525-539. https://doi.org/10.1016/j.cveq.2022.07.001
9. Dai S, Shiau D, Zilberschtein J et al. Correlation between acupuncture point sensitivity and front hoof thermography in horses: A preliminary investigation. Am J Trad Chin Vet Med 2023; 18(1):27-33. https://doi.org/10.59565/001c.77371
10. Dai S, Shiau D, Zilberschtein J. Correlation between acupuncture point LI-18 and PC-1 sensitivity and front hoof surface temperature in horses using infrared thermography. Am J Trad Chin Vet Med 2023; 18(2):9-15. https://doi.org/10.59565/001c.84478
11. Cai W, Chen A, Ding L et al. Thermal effects of acupuncture by the infrared thermography test in patients with tinnitus. J Acupunct Meridian Stud 2019; 12(4):131-135. https://doi.org/10.1016/j.jams.2019.05.002
12. Marcella K, Turner T, Riegel R et al. Guidelines for veterinary thermography. Am Acad Thermol 2021/revised 2022. https://aathermology.org/wp-content/uploads/2018/04/Guidelines-for-Veterinary-Thermography-2022.pdf /Accessed June 15, 2021
13. Çetinkaya M, Demirutku A. Thermography in the assessment of equine lameness. Turk J Vet Anim Sci 2012; 36(1):43-48. https://doi.org/10.3906/vet-1102-791
14. Palmer S. Effect of ambient temperature upon the surface temperature of the equine limb. Am J Vet Res 1983; 44(6):1098-1101.
15. Douthit T, Bormann J, Bello N. Assessing the association between hoof thermography and hoof doppler ultrasonography for the diagnosis of lameness in horses. J Equine Vet Sci 2014; 34(2):275-280. https://doi.org/10.1016/j.jevs.2013.06.005
16. Soroko M, Howell K. Infrared thermography: Current applications in equine medicine. J Equine Vet Sci 2018; 60:90-96. https://doi.org/10.1016/j.jevs.2016.11.002
17. von Schweinitz D. Thermographic evidence for the effectiveness of acupuncture in equine neuromuscular disease. Acupunct Med 1998; 16(1):14-17. https://doi.org/10.1136/aim.16.1.14
18. Um S, Kim M, Lim J et al. Thermographic evaluation for the efficacy of acupuncture on induced chronic arthritis in the dog. J Vet Med Sci 2005; 67(12):1283-1284. https://doi.org/10.1292/jvms.67.1283
19. Collins P. A randomized, blinded and controlled study using digital thermal imaging to measure temperature change associated with acupuncture in dogs with back pain. Am J Trad Chin Vet Med 2021; 16(2):1-10. https://doi.org/10.59565/001c.84095
20. Pan W. Bidirectional regulation of acupuncture and its plausible mechanisms. Acupuncture Research 2019; 44(11):843-853. (in Chinese). https://doi.org/10.13702/j.1000-0607.190260