Vol: 2, No: 2, (2023)

Antakya Veteriner Bilimleri Dergisi
The Journal of Antakya Veterinary Science
https://dergipark.org.tr/tr/pub/antakyavet

Araştırma makalesi / Research article

Thermographic evaluation of distal extremities in healthy horses

Elif Doğan[1a]*, Ayşe Başak Dellalbaşı[1b]

[1] *Kastamonu University, Veteriner Faculty, Department of Surgery, Kastamonu, Turkey*

MAKALE BİLGİSİ:
ARTICLE INFORMATION:

Geliş / Received:
26.10.2023
Revizyon/Revised:
22.11.2023
Kabul / Accepted:
05.12.2023
ORCIDS:
[a] 0000-0002-3321-8116
[b] 0000-0002-5796-5298

Thermographic evaluation of distal extremities in healthy horses

Abstract:

The use of infrared thermography to compare different surface temperatures is increasing. Therefore, our study aimed to compare the surface temperatures of distal extremities in healthy horses. In 6 healthy thoroughbred horses, temperature measurements were made by thermography on four surfaces (cranial, medial, lateral and caudal) of the metacarpo/ metatarsophalangeal joint and hooves. When the findings obtained were analyzed statistically no difference was found in joint and hoof surfaces. However, when the extremities were analyzed individually, the medial surface of the right hindlimbs was significantly higher than the caudal surface for articular surfaces. Although the cranial and lateral surfaces of the joint were not different from each other in the left hindlimbs, these two surfaces were significantly higher than the caudal surface. As a result, since the study was performed in healthy horses, it was thought that the significant increases between the surfaces were due to the inability to distribute the load evenly in the resting state. Since lesions may develop at these points over time, we suggest that thermographic scanning will contribute to the organization of horses' training programs.

Keywords: Distal extremities, Horse, Thermography

Sağlıklı atlarda distal ekstremitelerin termografik değerlendirmesi

Özet:

Farklı yüzey sıcaklıklarını karşılaştırmak için kızılötesi termografi kullanımı giderek artmaktadır. Bu nedenle, çalışmamızda sağlıklı atlarda distal ekstremitelerin yüzey sıcaklıklarının karşılaştırılması amaçlanmıştır. Sağlıklı 6 safkan atta, metakarpo/ metatarsofalangeal eklem ve toynakların dört yüzeyinde (kranial, medial, lateral ve kaudal) termografi ile sıcaklık ölçümleri yapıldı. Elde edilen bulgular istatistiksel olarak analiz edildiğinde, eklem ve toynak yüzeylerinde herhangi bir fark bulunmamıştır. Ancak, ekstremiteler ayrı ayrı analiz edildiğinde, eklem yüzeyleri için sağ arka bacakların medial yüzeyinin sıcaklığı kaudal yüzeyden önemli ölçüde daha yüksekti. Sol arka bacaklarda eklemin kranial ve lateral yüzeyleri birbirinden farklı olmamasına rağmen, bu iki yüzeyin sıcaklığı kaudal yüzeyden önemli ölçüde daha yüksekti. Sonuç olarak çalışma sağlıklı atlarda yapıldığı için yüzeyler arasındaki anlamlı sıcaklık artışlarının dinlenme durumunda yükün eşit dağılamamasından kaynaklandığı düşünülmüştür. Zaman içerisinde bu noktalarda lezyonlar gelişebileceğinden, termografik taramanın atların eğitim programlarının düzenlenmesine katkı sağlayacağını düşünmekteyiz.

Anahtar kelimeler: At, Distal Ekstremiteler, Termografi

Sorumlu Yazar / Corresponding Author: elifdogan@kastamonu.edu.tr

How to cite this article: Doğan E & Dellalbaşı AB (2023). Thermographic evaluation of distal extremities in healthy horses. *J. Antakya Vet. Sci.*, 2(2), 56-60.

Introduction

Applications of infrared thermography in veterinary medicine are increasing due to its non-contact nature and the rapid acquisition of real-time images (Salles et al., 2016). In addition to studies measuring different types of surface temperatures (Kotrba et al., 2007), thermography has also been used successfully in experiments, as it allows even tiny changes in surface temperatures to be seen (Bowers et al., 2009). The skin surface is reported to be an efficient radiator and suitable for detecting infrared emissions and determining their distribution (Purohit et al., 1985). Temperature patterns were observed by measuring different body parts (Montanholi et al., 2008).

Thermography is more accepted for diagnostic imaging of horses because it directly reflects surface temperature. Hot spots in these areas are related to increased metabolic activity in altered local blood circulation (Ring, 1990). Cold spots may be due to thrombosis, infarction, or decreased tissue perfusion (Eddy et al., 2001). Delahanty and Georgi (1965) were the first to use thermal imaging in horses and suggested that this method should be evaluated in conjunction with a number of factors. In clinical use, it has been reported that a high degree of symmetry is required for parts distal to the carpal and tarsal joints in horses (Purohit and McCoy, 1980). It has also been reported that thermographic evaluation of the distal parts of the extremities is complicated by the role of enhanced thermoregulation (Mogg and Pollitt, 1992). However, there are few studies investigating surface temperatures in healthy animals for the use of clinicians, and these studies are conducted on diseased tissues. Therefore, as a pilot study, our study aimed to compare distal extremity temperatures and different anatomical surfaces in healthy Thoroughbred horses.

Material and Methods

Animals and Measurements

This research study was carried out on six male thoroughbred horses aged 5-8 years on a private horse farm. The horses were confirmed to be healthy by veterinary examination (absence of inflammatory conditions causing temperature changes confirmed by clinical examination). Before the thermographic examination, the horses were kept quietly in their box for 20 minutes to avoid stress (Jerem et al., 2019). At the end of the period, the temperatures of the four surfaces of the metacarpophalangeal joint and the four surfaces of the nail were measured in the forelimbs, respectively. The same measurements were made on the hind limbs.

Surface temperatures were measured with a thermography device (FLIR-E6390, Systems, Inc., Sweden). The emissivity value was set to 0.97 εs, as stated in the literature (Rizzo et al., 2017). The distance between the horse and the camera was set to an average of 2 m to capture thermal images from the specified areas. Room temperature was maintained at 21°C for all procedures. The same thermography device was used for all imaging to reduce user error variability.

Statistical analysis

The sample size was not calculated for this study, as it was designed as a pilot study. The normality of the data was assessed using the Kolmogorov-Smirnov test, while the homogeneity of variances was evaluated through Levene's test. To ascertain disparities in measurement locations, a one-way analysis of variance (ANOVA) was employed. The results were expressed as means accompanied by their respective standard deviations, and the data analysis was executed utilizing SPSS 17.0 software (SPSS Inc., Chicago, IL, USA). The statistical analyses were conducted with a significance level set at $p < 0.05$.

Results

Regarding thermographic data, different surfaces of both the metacarpo/metatarsophalangeal joint and the hoof were compared within themselves. The thermographic points compared are shown in Figure 1. The temperatures (raw data) taken from the thermographic points are given in Table 1.

There was no significant difference between the temperatures measured on the cranial surfaces of the joints. Similarly, no significant difference was found when the joints' caudal, medial and lateral surface temperatures were analyzed. The same analyses were performed for the hoof, but there was no statistically significant difference when surface temperatures were evaluated (Table 2).

When the surfaces (cranial, caudal, medial, and lateral) in one joint of each horse were compared with each other, no significant differences were found in the right and left of the forelimb, while the medial surface temperatures were significantly higher than the caudal surface temperatures in the right hindlimb. Although the temperatures on the cranial and lateral surfaces were not different in the left hindlimb, these temperatures were significantly higher than the caudal surface temperatures (Table 3).

When the surfaces (cranial, caudal, medial, and lateral) of each horse's hoof were compared, no significant difference was found between the surface temperatures.

Table 1. Raw data from extremity surfaces.

Animal	Location	Surface	Forelimb-Right	Forelimb-Left	Hindlimb-Right	Hindlimb-Left
1	Joint	cranial	18,6	19,6	20,8	23,3
1		medial	21,7	18,5	23,7	20,9
1		lateral	21,1	22,7	20	22,9
1		cudal	18,5	17,9	16,7	19,1
1	Hoof	cranial	25,4	16,7	28,6	25,2
1		medial	25,8	29,2	29	28,6
1		lateral	29,3	27,6	27	26,6
1		caudal	20,3	19,91	19,8	23,4
2	Joint	cranial	19,2	18,5	20,1	19,1
2		medial	19,9	21,1	23,3	20,9
2		lateral	21,2	20	20,8	19,5
2		cudal	16,2	15,4	16,4	14,9
2	Hoof	cranial	25,5	16,9	28,2	25
2		medial	25,4	19,9	24,3	26,5
2		lateral	26,1	19,1	24,2	25,3
2		caudal	20,4	19,3	19,6	23,7
3	Joint	cranial	22,7	23,2	25,8	25,9
3		medial	26,8	25,4	26,3	26,5
3		lateral	27,3	27,6	26,2	24,6
3		cudal	24,4	23,1	24,1	22,5
3	Hoof	cranial	25,2	26,8	26	23,1
3		medial	24,4	25,5	24,8	26,4
3		lateral	23,6	25,9	26,6	24,4
3		caudal	28,8	31,7	32,2	30,6
4	Joint	cranial	14,6	14	15	23
4		medial	16,1	15,4	23,1	22,7
4		lateral	15	15,4	20,1	24,9
4		cudal	14,5	14,4	14,9	19,1
4	Hoof	cranial	17,3	14,7	15,7	26,1
4		medial	17,9	15	26,2	29,8
4		lateral	17	15,1	29,6	30
4		caudal	15,5	13,8	21,3	30,8
5	Joint	cranial	18,2	22,3	22,3	25,2
5		medial	21,7	18,5	21,6	20,9
5		lateral	21,1	22,7	20	22,6
5		cudal	19	18,8	16,7	19,7
5	Hoof	cranial	28,2	27,3	26,6	28,3
5		medial	25,8	29,2	29	28,6
5		lateral	29,3	27,6	27	26,6
5		caudal	28,1	24,4	27,8	27
6	Joint	cranial	14,6	14	15	23
6		medial	16,1	15,4	21,5	22,2
6		lateral	15	15,4	22,6	24,9
6		caudal	14,5	14,4	14,9	19,1
6	Hoof	cranial	17,3	14,7	15,7	26,1
6		medial	17,9	15	25,3	29,8
6		lateral	17	15,1	29,5	30
6		caudal	15,5	13,8	21,3	30,8

Table 2. Temperatures measured on the hoof surfaces of the forelimbs and hindlimbs.

Hoof	Forelimb-Right	Forelimb-Left	Hindlimb-Right	Hindlimb-Left	P value
Cranial	23,15±4,66	19,52±5,91	23,47±6,09	25,63±1,70	0,222
Medial	22,87±3,88	22,30±6,60	26,43±2,08	28,28±1,51	0,054
Lateral	23,72±5,63	21,73±6,02	27,31±2,02	27,15±2,35	0,108
Caudal	21,43±5,86	20,48±6,81	23,67±5,15	27,72±3,54	0,136
P value	0,881	0,872	0,315	0,290	

Table 3. Temperatures measured at the Metacarpo/Metatarso Phalangeal joint surfaces of the forelimbs and hindlimbs.

Metacarpo/ Metatarso Phalangeal Joint	Forelimb-Right	Forelimb-Left	Hindlimb-Right	Hindlimb-Left	P value
Cranial	17,98±3,07	18,60±3,95	19,83±4,23	23,25±2,37	0,071
Medial	20,38±4,04	19,05±3,79	23,25±1,75	22,35±2,17	0,114
Lateral	20,12±4,63	20,63±4,74	21,62±2,46	23,23±2,09	0,492
Caudal	17,85±3,74	17,33±3,37	17,28±3,44	19,06±2,43	0,766
P value	0,552	0,564	0,021	0,014	

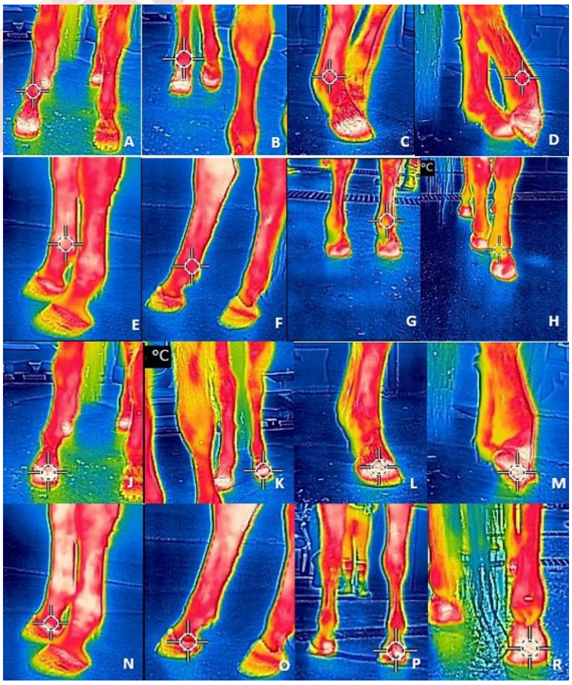

Figure 1. Anatomical surfaces with thermographic temperature measurements. **A:**Cranial surface of the metacarpophalangeal joint, **B;**Cranial surface of the metatarsophalangeal joint, **C;**Lateral surface of the metacarpophalangeal joint, **D;**Lateral surface of the metatarsophalangeal joint, **E;**Medial surface of the metacarpophalangeal joint, **F;**Medial surface of the metatarsophalangeal joint, **G;**Caudal surface of the metacarpophalangeal joint, **H;**Caudal surface of the metatarsophalangeal joint, **J;**Cranial surface of the forelimb hoof, **K;**Cranial surface of the hindlimb hoof, **L;**Lateral surface of the forelimb hoof, **M;**Lateral surface of the hindlimb hoof, **N;**Medial surface of the forelimb hoof, **O;**Medial surface of the hindlimb hoof, **P;**Caudal surface of the forelimb hoof, **R;**Caudal surface of the hindlimb hoof.

Discussion

The thermographic method, which precisely determines temperature changes that may indicate physiological responses to inflammatory disorders (Ciutacu et al., 2006), involves using a thermal camera to determine the surface temperatures of a horse (Tattersall and Cadena 2010). Since it is reported to be at least 10 times more sensitive than palpation on clinical examination (Turner, 2001), it was decided to use thermography in the pilot study presented. However, few objective studies have been published on body surface temperature as a baseline for clinicians (Head and Dyson, 2001). Given the fact that the normal thermographic pattern in healthy horses can be mapped to correspond to the location of superficial vessels (Turner, 1991), this pilot study aimed to visualize healthy distal extremities. For this purpose, temperature measurements were taken from the four surfaces of the metacarpo/metatarsophalangeal joint and the hoof.

Since the distal parts are unstable at low ambient temperatures due to the periodic cutaneous vasodilator effect (Mogg and Pollitt, 1992), the ambient temperature was kept at 21 ºC. Among these measurements, symmetry between the right and left limbs was also assessed. According to the literature, there should be symmetry between the right and left sides of the body for healthy animals (Palmer, 1983). According to our study results, there was no significant difference between the temperatures taken from the right and left distal extremities. This finding was expected since healthy animals were used in the study. On the contrary, thermography can provide valuable findings in the diagnosis of pathological conditions related to various inflammatory disorders. In the literature, it was reported that temperature changes of up to 1ºC in the compared regions were insignificant (Kold and Chappell, 1998) and that a difference of more than 1ºC in more than 25% of the measurement points in distal extremity temperatures should be considered abnormal (Turner, 1991). Although there was a difference of more than 1ºC in more than 25% of the surfaces measured in our study, it was not statistically significant. However, studies with a larger number of horses are needed to confirm this finding. Since our study is a pilot study, it provides information that will guide future studies.

It has been reported that the warmest surfaces in the extremities are on the medial, lateral and caudal surfaces (Vaden et al., 1980) due to the digital arteries. In the present study, we did not find a significant difference between the surfaces for the hoof, but we found differences in the hindlimbs at the metacarpo/metatarsophalangeal joint. We found that the medial surface was significantly higher than the caudal surface in the right hindlimbs. The same was true for the left hindlimbs, but here, the cranial surface was accompanied by the lateral surface. Since the horses used in the study were healthy, it was thought that these significant differences between surface temperatures could be due to the fact that carrying more weight at rest may cause a temperature increase (Soroko et al., 2014) over a long period of time.

In conclusion, thermographic screening before any clinical signs such as lameness appear can be of great benefit as it can detect hot and cold spots in the distal extremities. It should be considered that the temperatures on different surfaces in our study results may develop not only due to disease but also due to uneven distribution of the load. This is because these spots may develop different lesions after a long time. Regular thermographic screening should be performed. Since the points where temperature differences are determined are more sensitive, especially for the prevention of injuries, it will be possible to organize training programs in horses accordingly.

Acknowledgements: We would like to thank the authorities and staff of the horse farm for allowing us to collect data for this study.

Funding: The authors received no financial support for the research, authorship, and/or publication of this article.

Ethical approval: According to the Turkey legislation, there is no need to obtain local ethics committee permission for studies conducted without contact with animals. Therefore, local ethics committee permission was not obtained for our study. However, the study was conducted in accordance with European regulations (Directive 2010/63/EU).

Conflict of interest: The authors declare that there is no conflict of interest.

Author contribution: E.D: analyzed data for statistical significance, inline editing of the manuscript, performed scientific, prepared manuscript; A.B.D: contributed to the design of the study, recorded thermographic data and compiled all the data.

References

1. Bowers, S., Gandy, S., Anderson, B., Ryan, P., Willard, S., (2009). Assessment of Pregnancy in the Late-gestation Mare Using Digital Infrared Thermography. Theriogenology, 72(3), 372-377. https://doi.org/10.1016/j.theriogenology.2009.03.005
2. Ciutacu, O., Tanase, A., Miclaus, I. (2006). Digital infrared thermography in assessing soft tissue injuries on sport equines. Bulletin of University of Agricultural Sciences and Veterinary Medicine 63, 228-233. https://doi.org/10.15835/BUASVMCN-VM:63:1-2:2482
3. Delahanty, DD., Georgi, JR. (1965). Thermography in equine medicine. Journal of the American Veterinary Medical Association, 147, 235. PMID: 14325456
4. Eddy, AL., van Hoogmoed, LM. Snyder, JR. (2001). The role of thermography in the management of equine lameness. Veterinary Journal, 162, 172-181. https://doi.org/10.1053/tvjl.2001.0618
5. Head, J., Dyson S. (2001). Taking the temperature of equine thermography. The Veterinary Journal, 162,166-167. https://doi.org/10.1053/tvjl.2001.0639
6. Jerem, P., Jenni-Eiermanni S., McKeegan, D., McCafferty, DJ., Nager, RG. (2019) Eye region surface temperature dynamics acute stress relate to baseline glucocorticoids. Physiology & Behavior. 210,112627. https://doi.org/10.1016/j.physbeh.2019.112627
7. Kold, SE., Chappell KA. (1998). Use of computerized thermographic image analysis (CTIA) in equine orthopedics: review and presentation of clinical cases. Equine Veterinary Education, 10,198-204. https://doi.org/10.1111/j.2042-3292.1998.tb00877.x
8. Kotrba, R., Knízková, I., Kunc, P., Bartos, L. (2007). Comparison between the coat temperature of the eland and dairy cattle by infrared thermography. Journal of Thermal Biology, 32(6), 355-359. https://doi.org/10.1016/j.jtherbio.2007.05.006
9. Montanholi, YR., Nicholas, EO., Kendall, CS., Schenkel, FS., Mcbride, BW., Miller,
10. SP. (2008). Application of infrared thermography as an indicator of heat and methane production and its use in the study of skin temperature in response to physiological events in dairy cattle (Bos taurus). Journal of Thermal Biology, 33(8), 468-475. https://doi.org/10.1016/j.jtherbio.2008.09.001
11. Mogg, KC., Pollitt, CC. (1992). Hoof and distal limb surface temperature in the normal pony under constant and changing ambient temperatures. Equine Veterinary Journal, 24,134-139. https://doi.org/10.1111/j.2042-3306.1992.tb02798.x.
12. Palmer, SE. (1983). Effect of ambient temperature upon the surface temperature of equine limb. American Journal of Veterinary Research, 44,1098-1101. PMID: 6870013
13. Purohit, RC., Hudson, RS., Riddell, MG., Carson, RL., Wolfe, DF., Walker, DF. (1985). Thermography of the bovine scrotum. American Journal of Veterinary Research, 46, 2388-2392. PMID: 4073651, Corpus ID: 3045328
14. Purohit, RC., McCoy, MD. (1980). Thermography in the diagnosis of inflammatory processes in the horse. American Journal of Veterinary Research, 41, 1167-1174. PMID: 7447110
15. Ring, EF. (1990) Quantitative thermal imaging. Clinical Physics and Physiological Measurement, 11, 87-95. https://doi.org/10.1088/0143-0815/11/4a/310.
16. Rizzo, M., Arfuso, F., Alberghina, D., Giudice, E., Gianesella, M., Piccione G. (2017). Monitoring changes in body surface temperature associated with treadmill exercise in dogs by use of infrared methodology. Journal of Thermal Biology, 69, 64-68. https://doi.org/10.1016/j.jtherbio.2017.06.007
17. Salles, MSV., Silva, SC., Salles, FA., Roma, LC., Faro, L., Lean, PABM., Oliveira, CEL., Martello, LS. (2016). Mapping the body surface temperature of cattle by infrared thermography. Journal of Thermal Biology, 62, 63-69. https://doi.org/10.1016/j.jtherbio.2016.10.003
18. Soroko, M., Dudek, K., Howell, K., Jodkowska, E., Henklewski, R. (2014). Thermographic evaluation of racehorse performance. Journal of Equine Veterinary Science, 34,1076-1083. https://doi.org/10.1016/j.jevs.2014.06.009
19. Tattersall, GJ., Cadena, V. (2010). Insights into animal temperature adaptations revealed through thermal imaging. The Imaging Science Journal, 58, 261-268. https://doi.org/10.1179/136821910X12695060594165
20. Turner, TA. (1991). Thermography as an aid to the clinical lameness evaluation. Veterinary Clinics of North America: Equine Practice, 7, 311-338. https://doi.org/10.1016/s0749-0739(17)30502-3
21. Turner, TA. (2001). Diagnostic thermography. Veterinary Clinics of North America: Equine Practice, 17, 95-113. https://doi.org/10.1016/s0749-0739(17)30077-9