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The Effectiveness of Thermography in Determining Localization of Orthopedic Diseases in Horses

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ABSTRACT Infrared thermographic imaging of horses is becoming more popular in equine practice, and it is regarded to be a valuable method for detecting lesions with the potential to cause lameness. The current study aimed to investigate the effectiveness of thermal camera in determine the location of lesions in horses with lameness. Twenty four Arabian horses aged 6.3±1.8 (mean±standard deviation) years old were included in this study. Temperature measurements were obtained with a thermal camera on the fore and hindlimb of all horses with lameness and the area where the temperature increased (suspected area) was detected. Following the suspected area was determined, temperature measurements were performed in the symmetric area of the same animal. All thermal camera temperatures were taken from four different points (lateral, medial, dorsal, palmar/plantar) and the average of measurements was recorded. The mean temperature measurement in the suspected area (34.7±1.7 °C) was significantly higher than the symmetric area (31.8±2.1 °C) in horses ($p<0.001$). In conclusion, thermography can be used to determine rapidly and effectively the localization of the orthopedic lesion in horses.

Keywords: *Horse, Lameness, Lesion, Temperature.*

ÖZ

Atlarda Ortopedik Hastalıkların Lokalizasyonunu Belirlemede Termografinin Etkinliği

Atların kızılötesi termografik görüntülemesi, at hekimliğinde oldukça popüler hale gelen ve atlarda topallığa neden olma potansiyeline sahip lezyonları tespit etmek için kullanılan yararlı bir yöntem olarak kabul edilmektedir. Bu çalışmanın amacı, topallığı olan atlarda lezyonların yerini belirlemede termal kameranın etkinliğini araştırmaktı. Bu çalışmaya 6.3±1.8 (ortalama±standart sapma) yaşındaki toplam yirmi dört Arap atı dahil edildi. Topallığı olan tüm atların ön ve arka bacaklarında termal kamera ile sıcaklık ölçümleri yapılarak sıcaklığın arttığı bölge (şüpheli bölge) belirlendi. Şüpheli bölge belirlendikten sonra aynı hayvanın simetrik bölgesinde sıcaklık ölçümleri yapıldı. Tüm termal kamera sıcaklıkları 4 farklı noktadan (lateral, medial, dorsal, palmar/plantar) alındı ve ölçümlerin ortalaması kaydedildi. Atlarda şüpheli alandaki (34.7±1.7 °C) ortalama sıcaklık ölçümü simetrik alandan (31.8±2.1 °C) istatistiksel olarak önemli ölçüde yüksek olarak belirlendi ($p<0.001$). Sonuç olarak, termografi atların ortopedik lezyonlarının lokalizasyonunu belirlemede hızlı ve etkin bir yöntem olarak kullanılabilir.

Anahtar Kelimeler: *At, Lezyon, Sıcaklık, Topallık.*

INTRODUCTION

Lameness is a major medical problem in equine veterinary medicine that is defined as an abnormal stance or gait caused by mechanical dysfunction or neuromuscular deficit and can lead to economic loss to horse owners (McCracken et al. 2012; Feuser et al. 2022). Pathognomonic motion impairments in some cases allow effortless detection and localization of the problem. However, in most of the cases distinct gait abnormalities do not exist, making diagnosis difficult (Dyson et al. 2005; Davidson 2018). Detection of lesions that can cause lameness is crucial for employing the proper treatment. Thus, the assessment of lameness should be carried out systematically and methodically. Unfortunately, this procedure can take a long time, especially if the underlying problem is not identifiable (Davidson 2018).

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Despite considerable technological developments in equine medicine over the last three decades, diagnostic analgesia is still likely the most helpful technique in veterinary clinicians to detect pain that induces lameness (Lance et al. 2010). However, false-negative responses and misdiagnosis to local analgesic administration may occur due to a variety of causes, including the following: incorrect injection, insufficient time for the local anesthetic solution to be effective, severe pain in the injection side, failure to employ the suitable nerve blocks, neuropathic pain (Dyson 2010).

Thermography is a non-contact, non-invasive screening technique that converts the surface temperature of the object identified as thermal images and has been regarded as an effective method for detecting lesions with the potential to induce lameness (Holmes et al. 2003; Cetinkaya and Demirutku 2012). Unlike the radiography and ultrasonography, it is a physiological diagnostic imaging method (Turner 1991; Cetinkaya and Demirutku 2012). Moreover, this technique enables the diagnosis of anatomical abnormality caused by the inflammation (Soroko et al. 2013). It has been stated that thermography diagnoses subclinical inflammation until two weeks before the onset of clinical lameness and swelling in horses with lameness (Turner et al. 2001).

This study aimed to investigate the effectiveness of thermography in determining the localization of the lesion that causes lameness in Arabian horses.

MATERIAL AND METHODS

All procedures described in the current study were performed at the Ataturk University Animal Hospital after the permission of Ataturk University Local Board of Ethics Committee (decision no: 272 2022/13) and with the informed consent of owners. This study was conducted by the guidelines of the National Institutes of Health Guide for the care and Use of Laboratory Animals (National Research Council 2010). Twenty four client-owned Arabian horses (7 females and 17 males) were included in the study based on the following inclusion criteria: no evidence of aggressive behavior, the existence of any orthopedic problem from hoof to the carpal/tarsal region,and displaying lameness in only one fore-hindlimb without a previous treatment.

Thermographic examination

Before the examination, each horse was acclimatized for 20 minutes into the closed room without direct sunshine, and a mean temperature of 25.5±1 °C. The same person took all measurements. The thermal camera (IR Flexcam S; Infrared Solutions Incorporated, Plymouth, MN, USA) was placed 1.0 m from the suspected region, and no anesthetic drugs were administered during examinations (Figure 1 and 2). Both limbs were firstly scanned for possible detection of increased or decreased temperature region (suspected area) in four different views (dorsal, palmar/plantar, medial, lateral) from the carpal/tarsal joint to the hoof. Then, the maximum value temperature of the suspected area was recorded from four different views (medial, lateral, dorsal, and palmar/plantar), which was also considered temperature of the associated region. The central temperatures of the contralateral limb were recorded for comparison.

Radiological examination

The radiographic (Mex-100, Medical ECONET, Oberhausen, Germany) and ultrasonographic (Vivid 5SN, General Electric, Horten, Norway) examinations of the related regions were performed to determine the cause of lameness (Figure 1).

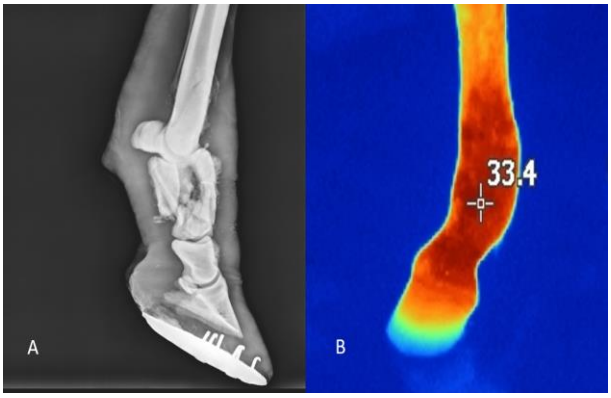

Figure 1. Case 2; radiographic (A) and thermographic (B) image of the localization of the lesion.

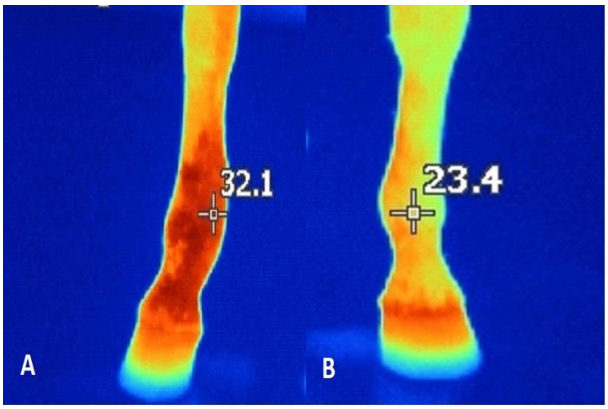

Figure 2. Case 19; to compare suspected (A) and symmetric (B) area temperatures, both limbs were measured by the thermal camera in a horse.

Statistical Analysis

Power analysis was calculated to detect sample size. The study power of 90% (β) with an error of 0.05 (α) was required to identify a 3°C difference in average temperature between suspected and symmetric areas. The analysis demonstrated that twenty horses would be necessary. This calculation was based on a study by Yanmaz (Yanmaz 2018), in a study comparing the temperature of the limb with/without lesions in horses. Statistical analysis was employed using Medcalc version 20.011 (Medcalc Software, Ostend, Belgium). The distribution data of quantitative variables was tested before research by the Shapiro-Wilk test. The independent sample *t*-test was performed to evaluate the difference between suspected and symmetric area temperatures. All data were expressed in mean±standard deviation and the p-value of <0.05 was considered statistically significant.

RESULTS

All thermographic examination wascompleted without complication. Because of inaccurate focusing, the first measurement attempt failed, and a second measurement attempt was performed to collect readings from four horses during the thermographic examination. All horses had different levels of unilateral lameness and/or reluctance to exercise or utilize their extremities. Radiography and ultrasonography were used to confirm the exact diagnosis in 19 and 5 cases, respectively. Temperature changes could not be detected in only 1 point out of 19 cases of bone tissue related diseases. In contrast

3 out of 5 cases of soft tissue related diseases could not be seen by thermographic examination.

The mean age of horses was 6.3±1.8, ranging from 4 to 11 years old. The causes of horse lameness were determined as a proximal sesamoid fracture (n=4), overgrowth bone exostosis (n=4), osteochondrosis dissecans (n=4), superficial digital flexor tendon enthesopathy (n=3), proximal phalanx fracture (n=3), sesamoiditis (n=2), degenerative joint lesion of the fetlock (n=2), bucked shin complex (n=1), and carpal osteoarthritis (n=1). In all cases, the increased temperature was identified in the suspected area by thermographic examination, and radiographic and ultrasonographic evaluation confirmed the diagnosis. Additionally, no temperature difference was observed between suspected and symmetric areas in four cases (superficial digital flexor tendon enthesopathy, carpal osteoarthritis, osteochondrosis dissecans, and degenerative joint lesion of the fetlock, Table 1).

A significant difference was found between suspected (34.7±1.7 °C) and symmetric (31.8±2.1 °C) areas at the mean temperature measurement ($p<0.001$). In the thermographic temperature measurement, the suspected area temperature tended to measure ranged from 0.6 to 5.3 °C higher compared to the symmetric area.

Table 1. The mean temperature (lateral, medial, dorsal, and palmar/plantar) of suspected and symmetric area, and diagnosis causing temperature increase.

Case No	Age	Gender	Mean Temperature of Suspected Area (°C)	Mean Temperature of Symmetric Area (°C)	Diagnosis
1	7	M	34.1	29.9	SDFTE
2	4	M	36.2	32.9	PPBF
3	9	F	35.6	33.5	BSC
4	5	M	35.5	30.2	OCD
5	9	M	35.8	30.6	PSBF
6	4	F	33.4	30.8	OBE
7	11	M	37.3	33.9	SS
8	4	M	-	-	SDFTE
9	5	F	-	-	CO
10	6	M	35.9	33.8	OBE
11	7	M	33.1	29.1	PPBF
12	8	M	33.7	31.7	OCD
13	5	F	-	-	OCD
14	6	M	36.0	34.3	PPBF
15	4	M	36.5	35.9	PSBF
16	5	M	34.9	32.8	OBE
17	7	M	-	-	DJLF
18	5	M	32.4	29.3	PSBF
19	6	F	32.1	23.4	DJLF
20	6	F	36.3	32.6	OCD
21	8	M	36.4	34.6	PSBF
22	6	M	33.4	32.1	SDFTE
23	6	F	32.2	29.3	SS
24	8	M	33.7	29.3	OBE

M; male, F; female, SDFTE; Superficial digital flexor tendon enthesopathy, PPBF; Proximal phalanx bone fracture, BSC; Bucked Shin Complex, OCD; Osteochondrosis dissecans, PSBF; Proximal sesamoid bone fracture, OBE; Over growth bone exostosis, SS; Sesamoiditis, CO; Carpal osteoarthritis, DJLF; Degenerative joint lesion of the fetlock, -; undetectable temperature difference.

DISCUSSION AND CONCLUSION

The current study demonstrated that the thermal camera is a rapid and effective method for determining the localization of lesions in horses with fore and hindlimb lameness with no clinical symptoms. Additionally, the thermographic examination determined that temperature measurement was significantly increased in the suspected area compared to the symmetric area in bone and tendon disease.

One of the most important physical characteristics of the inflammatory process is the change in tissue temperature. The thermal camera is a non-invasive diagnostic imaging device that defines inflammation and has many advantages such as easily monitoring temperature in uncooperative or aggressive animals. In addition, thermography can provide us with basic information about the localization of the lesion (Fabbri et al. 2022; Okur and Okumus 2022). Previous studies have reported that thermographic examination has served in the diagnosis of a variety of limb trauma involving inflammation of the stifle (Purohit

et al. 2006), carpal and tarsal joint (Bowman et al. 1983), tendinopathy (Turner 2001), and bucked shin complex (Yanmaz 2018). Similarly, in our study, in 20 of 24 cases, the thermal camera was achieved to determine the location of the lesion and support diagnosing bone and tendon diseases.

The healthy horse's usually high degree of symmetry between contralateral areas of the body is a valuable asset in the diagnosis of unilateral pathological conditions associated with various inflammatory diseases (Soroko and Howell 2018). Therefore, the temperatures of the symmetrical areas were measured to compare the suspected areas in the current study. Although temperature asymmetry may demonstrate deformity, temperature differences of up to 1 °C between comparing areas of the body are considered normal (Verschooten et al. 1997). According to the study by Turner (Turner 1991), a difference of more than 1 °C over 25% of the compared distal parts of the limbs was considered abnormal. Similarly, another study conducted by Soroko et al. (Soroko et al. 2013) reported that temperature changes of 1.25 °C between the distal regions of the right and left limbs in racehorses could suggest subclinical inflammation of the superficial digital flexor tendon and metacarpus. Consistent with these results, in our study, a difference of more than 1 °C was found between the suspected and the symmetric area in 95% of our cases.

In our study, temperature measurements of suspected areas were increased compared with symmetrical areas due to inflammatory processes caused by various diseases. Diseases causing this temperature increase were diagnosed by radiography and ultrasonography following thermographic examination. In agreement with our results, previous studies demonstrated that thermography has a significant success rate for diagnosis when combined with radiography and ultrasonography (Eddy et al. 2001; Turner 2001; Cetinkaya and Demirutku 2012). In our study, despite the radiographic or ultrasonographic diagnosis of the diseases, no temperature increase was detected by the thermal camera in 4 cases. This could be explained by the chronicity of the cases, which may lead to lower temperature differences between normal and healthy tissues.

In conclusion, although the thermal camera is not a direct diagnostic tool, it quickly and easily determines the location of the lesion by detecting the temperature changes over the related region. Using thermography with other standard lameness radiology modalities, such as radiography and ultrasonography, would increase the diagnostic capability of equine orthopedic diseases

CONFLICTS OF INTEREST

The authors report no conflicts of interest.

AUTHOR CONTRIBUTIONS

Supervision / Consultancy: SO, MGS, ÖTO, YK
Data Collection and / or Processing: SO, AG, UE
Writing the Article: SO, AG
Critical Review: LEY, MGS, UE
Idea / Concept: SO, LEY, AG

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