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RESEARCH ARTICLE

Association of Distal Extremity Thermographic Temperatures with Lameness in Cattle

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Abstract

Early diagnosis of foot diseases with lameness in cattle farms contributes to animal welfare and economy. Since early diagnosis of foot diseases characterized by lameness is very important, this study aimed to compare lameness scores and thermal temperatures in cattle. While lameness scoring was performed in ten cows (3-5 years old), thermal temperatures were measured from 280 points (right and left limbs) in the foot regions. Before lameness scoring, the gait of the cows was video recorded. Then, the recordings were watched and scored by two observers. Animals were taken to a shaded area for thermographic examination, and thermal records were kept. The temperature values obtained from the thermal camera represent the highest temperature in the anatomical regions. Pearson's correlation coefficient (r) through a bivariate linear regression model was used to investigate the relationship between lameness score and hoof temperature. In addition, the correlation between different anatomical regions was also analyzed. The analysis revealed no significant correlation between the lameness score and any specific region on the hoof or limb. However, significant correlations were found between anatomical areas. According to the data obtained from the Forelimb, the dorsal surface of the lateral hoof (R1) had a high correlation with the dorsal surface of the interdigital area (R5). Similarly, a high correlation was found between the dorsal surface of the medial hoof (R3) and the posterior surface of the interdigital area (R7). In the data obtained from the Hindlimb, two regions were identified where the dorsal surface of the lateral hoof (R2) had a high correlation: the dorsal surface of the medial hoof (R4) and the dorsal surface of the interdigital area (R6). In conclusion, if thermography detects temperature increases before illnesses occur, appropriate measures can be taken. According to the study's findings, it was determined that thermography could be a guide in methods such as lameness scoring and can play an effective role in taking precautions in preventive medicine.

Key Words: Cattle, lameness, score, thermography

Sığırlarda Distal Ekstremite Termografik Sıcaklıklarının Topallık ile İlişkisi

Öz

Sığır çiftliklerinde topallıkla seyreden ayak hastalıklarının erken teşhisi hem hayvan refahına hem de ekonomiye katkı sağlar. Topallıkla karakterize ayak hastalıklarının erken teşhisi çok önemli olduğundan, bu çalışma sığırlarda topallık skorlarını ve termal sıcaklıkları karşılaştırmayı amaçlamıştır. Toplam on inekte (3-5 yaş arası) topallık skorlaması yapılırken, ayak bölgelerinde toplam 280 noktadan (sağ ve sol uzuvlar) termal sıcaklıklar ölçülmüştür. Topallık skorlamasından önce ineklerin yürüyüşü videoya kaydedilmiştir. Daha sonra kayıtlar iki gözlemci tarafından izlenmiş ve puanlanmıştır. Termografik inceleme için hayvanlar gölgelik bir alana alınmış ve termal kayıtlar tutulmuştur. Termal kameradan elde edilen sıcaklık değerleri, anatomik bölgelerdeki en yüksek sıcaklığı temsil etmektedir. Topallık skoru ile tırnak sıcaklığı arasındaki ilişkiyi araştırmak için iki değişkenli doğrusal regresyon modeli aracılığıyla Pearson korelasyon katsayısı (r) kullanılmıştır. Ayrıca, farklı anatomik bölgeler arasındaki korelasyon da analiz edilmiştir. Analiz, topallık skoru ile tırnak veya distal ekstremite üzerindeki herhangi bir spesifik bölge arasında anlamlı bir korelasyon olmadığını ortaya koymuştur. Bununla birlikte, anatomik bölgeler arasında anlamlı korelasyonlar bulunmuştur. Ön ayaklardan elde edilen verilere göre lateral tırnağın dorsal yüzeyi (R1) interdigital alanın dorsal yüzeyi (R5) ile yüksek bir korelasyona sahipti. Aynı şekilde medial tırnağın dorsal yüzeyi (R3) ile interdigital alanın arka yüzeyi (R7) arasında yüksek bir korelasyon belirlendi. Arka ayaklardan elde edilen verilerde lateral tırnağın dorsal yüzeyinin (R2) yüksek korelasyona sahip olduğu iki bölge belirlendi; medial tırnağın dorsal yüzeyi (R4) ve interdigital bölgenin dorsal yüzeyi (R6). Sonuç olarak, termografi hastalıklar oluşmadan önce sıcaklık artışını belirleyebilmek için kullanılırsa gerekli önlemler alınabilir. Çalışma bulgularına göre Termografinin topallık skorlaması gibi yöntemlerde yol gösterici olabildiği ve koruyucu hekimlikte önlemlerin alınmasında etkin bir rol oynayabileceği belirlenmiştir.

Anahtar Kelimeler: Sığır, skor, termografi, topallık

INTRODUCTION

Lameness in ruminants is a significant problem affecting health and welfare in the livestock industry. Lameness, which has a multifactorial etiology, deficient hygiene, and high humidity in stables, can be effective by creating ideal conditions for bacterial growth (1). Early diagnosis is crucial for preventing lameness and immediate treatment of clinical signs (2). Diagnosis is usually made during hoof trimming after the cow has started to limp (3), which is economically inefficient. There are several methods to diagnose foot diseases. Several ways have been used to diagnose cases of lameness in dairy cattle, such as mobility scoring, which refers to a structured subjective assessment of a cow's gait (4). However, besides being time-consuming, they are personal, and there is no standard for evaluation (5). This method is inexpensive and does not require direct contact with the animal. Therefore, it is used as a screening method for lameness assessment in cattle herds. Individual clinical examination may then be necessary (6).

Infrared thermography is a non-invasive, radiation-free, rapidly developing diagnostic method that measures surface temperature and represents it as a color scale. It is used to detect local temperature abnormalities on the skin surface by capturing infrared radiation that can directly correlate with the surface temperature of a part of the body. It has been reported that the lesioned hoof has a higher surface temperature than the healthy one (7). It has been shown that there is almost no temperature difference between an animal's right and left limbs. Some authors have reported that a difference of 1 °C may indicate a pathological process (8). This technique helps assess inflammatory changes and is particularly useful for diagnosing lameness and localization of lesions. Therefore, using it for early control before clinical symptoms appear is useful (9).

Based on the given literature information, this study aimed to investigate the benefits of using digital infrared thermal imaging as an early detection tool in a small-scale dairy farm to correlate lameness scores of cattle with thermographic data from different regions and to provide early treatment or control since the increase in temperature indicates an inflammatory condition at that point, even if there is no clinical symptom, the cause of lameness can be determined in advance. Thus, by comparing the thermographic imaging method with the clinical lameness scoring method, it was hypothesized that thermography may be advantageous.

MATERIAL AND METHODS

Animals and Lameness Scoring

The study was conducted in a small-scale dairy cattle enterprise in Kastamonu province in September 2023. According to the legislation of our country, local ethics committee permission is not required for studies conducted without contact with animals. Therefore, our study did not obtain permission from the local ethics committee. However, the study followed European regulations (Directive 2010/63/EU).

Ten cows in a dairy farm (Holstein, 3-5 years old, mean body weight 450-650 kg) were enrolled in the study. First, the animals were filmed from different viewing positions while walking on a concrete floor (20 meters) inside the semi-open enclosure. GoPro Hero 12 Black camera (GoPro Inc., San Mateo, California) was used for video recordings. Two observers examined the recordings to determine lameness according to the scale defined by Sprecher et al. (10) (Score 1: Normal, Score 2: Mildly Lame, Score 3: Moderately Lame, Score 4: Lame, Score 5: Severely Lame).

Infrared Thermography Examination

Animals were taken to a covered area (ambient temperature 25°C) for evaluation in the shade, and thermal camera images were taken (Flir E6390, Sweden). A total of 280 thermographic images (right and left limbs, clean hoof with no coarse dirt) were taken from 10 cows. The emissivity value for subjects was 0.93, and all images were taken at the same distance (2 meters) (11). The points where thermographic images were taken are given in Figure 1, and their abbreviations are shown in Table 1.

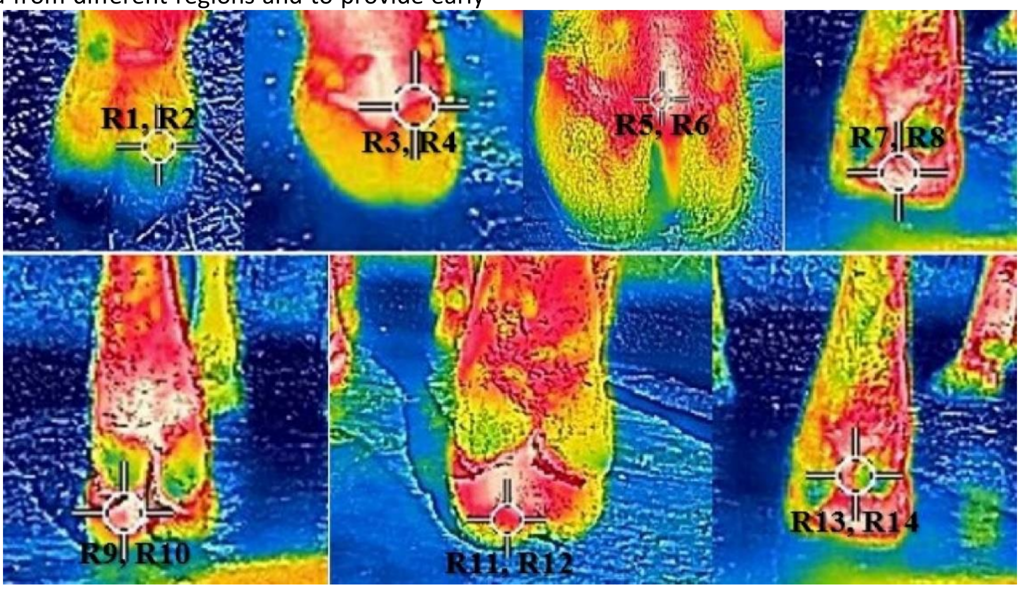

Figure 1. Anatomical points where thermographic temperatures are measured. Odd numbers refer to the forelimbs, and even numbers refer to the hindlimbs. **R1, R2;** Dorsal surface, lateral hoof, **R3, R4;** Dorsal surface medial hoof, **R5, R6;** Interdigital dorsal surface, **R7, R8;** Interdigital posterior surface, **R9, R10;** Heel lateral, **R11, R12;** Heel medial, **R13, R14;** Between the dew claw

Table 1. Thermography image points and abbreviations

Abbreviation	Thermographic image point
R1	Dorsal surface, lateral hoof forelimb
R2	Dorsal surface, lateral hoof, hind limb
R3	Dorsal surface medial hoof forelimb
R4	Dorsal surface medial hoof hind limb
R5	Interdigital dorsal surface, forelimb
R6	Interdigital dorsal surface, hind limb
R7	Interdigital posterior surface forelimb
R8	Interdigital posterior surface hind limb
R9	Heel lateral forelimb
R10	Heel lateral hind limb
R11	Heel medial forelimb
R12	Heel medial hind limb
R13	Between the dew claw forelimb
R14	Between the dew claw hind limb

In the study, the arithmetic mean of temperature measurements obtained from the right and left front hooves was taken as the data for the forelimb temperature, and the arithmetic mean of temperature measurements obtained from the right and left hind hooves was taken as the data for the hindlimb temperature.

Statistical Analysis

Pearson's correlation coefficient (r) was employed through a bivariate linear regression model to investigate the relationship between lameness score and hoof temperature. All correlation coefficients were reported with an alpha level set at 0.05, indicating the significance level of the findings. The statistical analysis was conducted using SPSS software (Version 22, IBM Corp., Armonk, NY, USA).

RESULTS

The study was completed with all the values in the dataset. The analysis revealed no significant correlation between lameness score and any specific location on the hoof or leg (p > 0.05). However, noteworthy correlations were identified between certain aspects of the foot and the legs. The lameness scores and measured thermographic values are given in Table 2.

Table 2. Lameness scores and thermographic temperatures from anatomical regions

			Dorsal Surface				Interdigital Dorsal Surface		Interdigital Posterior Surface		Heel				Between the dew claws	
			Lateral Hoof		Medial Hoof						Lateral Hoof		Medial Hoof			
			Fore limb	Hind limb	Fore limb	Hind limb	Fore limb	Hind limb	Fore limb	Hind limb	Fore limb	Hind limb	Fore limb	Hind limb	Fore limb	Hind limb
Animal	Lameness score		R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14
1	1	Right	21.68	21.65	21.54	21.73	22.76	22.76	23.41	22.60	22.14	24.30	21.78	26.10	21.93	26.00
1	1	Left	21.68	21.65	21.54	21.73	22.76	22.76	23.41	27.60	22.14	28.40	21.78	21.90	21.93	28.20
2	2	Right	26.30	21.65	21.54	21.73	28.30	22.76	23.41	31.90	22.14	30.40	21.78	32.40	21.93	22.00
2	2	Left	23.30	21.65	21.54	21.73	30.30	22.76	23.41	28.80	22.14	30.30	21.78	33.30	21.93	23.90
3	1	Right	27.10	29.60	29.20	28.80	29.00	29.80	28.70	20.14	26.20	20.01	26.00	20.11	22.00	19.39
3	1	Left	26.90	23.90	28.00	25.10	31.10	29.50	26.10	20.14	25.40	20.01	21.90	20.11	16.80	19.39
4	2	Right	15.40	26.00	14.00	24.30	15.90	30.90	23.40	14.30	27.30	13.40	20.90	13.50	12.80	15.10
4	2	Left	15.50	25.70	24.00	28.80	12.70	32.10	21.20	12.30	18.90	12.70	24.00	12.00	22.90	12.60
5	1	Right	14.00	14.10	15.10	13.30	15.60	13.60	16.40	14.70	15.10	13.90	16.50	14.10	17.30	14.80
5	1	Left	15.70	14.40	14.50	15.20	16.00	15.60	16.40	14.40	15.10	15.20	14.90	15.00	17.10	12.90
6	1	Right	21.40	21.80	24.00	22.80	25.80	24.90	26.00	22.80	23.70	19.50	24.50	22.90	25.80	22.40
6	1	Left	29.00	21.60	21.00	24.50	21.10	23.20	24.00	21.70	22.10	21.60	25.20	22.60	26.30	22.30
7	3	Right	21.60	14.80	24.00	16.50	24.30	15.10	27.30	16.20	24.40	13.90	22.80	15.80	25.00	15.70
7	3	Left	21.30	20.50	19.00	20.40	20.40	19.70	23.70	16.40	23.30	16.80	22.00	16.40	23.50	17.80
8	1	Right	26.00	21.30	25.80	20.20	27.30	17.90	29.40	18.90	23.30	17.60	27.30	19.50	26.80	16.90
8	1	Left	20.90	21.50	22.60	22.40	21.50	21.80	23.80	21.80	23.30	19.90	21.80	17.10	22.90	18.80
9	2	Right	22.10	21.70	17.90	20.90	23.00	22.80	18.50	17.80	19.00	17.70	18.30	16.40	21.40	18.30
9	2	Left	21.50	22.10	20.20	18.30	20.40	22.70	20.30	17.70	20.00	19.40	18.60	20.70	20.10	16.80
10	3	Right	20.00	23.50	21.90	21.60	23.90	23.30	25.80	20.70	24.00	21.90	21.30	20.40	25.20	21.80
10	3	Left	22.30	23.90	23.40	24.50	23.00	21.20	23.60	22.00	23.10	23.20	22.40	21.80	24.90	22.80

In the Forelimb, the dorsal surface of the lateral hoof (R1) had a high correlation with the dorsal surface of the interdigital area (R5) (R=0.803), a moderate correlation with the dorsal surface of the medial hoof (R3) (R=0.662), the posterior surface of the interdigital area (R7) (R=0.629) and the medial heel (R11) (R=0.610) and a weak correlation with the lateral heel (R9) (R=0.483) and between the dew claws (R13) (R=0.475). The dorsal surface of the medial hoof (R3) had a high correlation with the posterior surface of the interdigital area (R7) (R=0.670) and the medial heel (R11) (R=0.760), a moderate correlation with the lateral heel (R9) (R=0.528), between the dew claws (R13) (R=0.525).

The dorsal surface of the interdigital area (R5) had a moderate correlation with the posterior surface of the interdigital area (R7) (R=0.656), the lateral heel (R9) (R=0.531), and the medial heel (R11) (R=0.448). The posterior surface of the interdigital area (R7) had a high correlation with the lateral heel (R9) (R=0.857) and the medial heel (R11) (R=0.868), a moderate correlation between the dew claws (R13) (R=0.503).

Finally, a moderate correlation was found between the temperature of the lateral (R9) and medial heels (R11) (R=0.667), as well as between the temperature of the medial heel (R11) and the temperature between the dew claws

(R13) (R=0.634). The correlation coefficients for the Forelimb are shown in Table 3.

Table 3. Forelimb correlations

Anatomical Location 1	Anatomical Location 2	Correlation coefficient	P value
R1	R3	0.662	p = 0.001
R1	R5	0.803	p < 0.01
R1	R7	0.629	p = 0.003
R1	R9	0.483	p = 0.031
R1	R11	0.610	p = 0.004
R1	R13	0.475	p = 0.034
R3	R7	0.670	p = 0.001
R3	R8	0.779	p < 0.01
R3	R9	0.528	p = 0.017
R3	R11	0.760	p < 0.01
R3	R13	0.525	p = 0.018
R5	R7	0.656	p = 0.002
R5	R9	0.531	p = 0.016
R5	R11	0.448	p = 0.047
R7	R9	0.857	p < 0.05
R7	R11	0.868	p < 0.01
R7	R13	0.503	p = 0.024
R9	R11	0.667	p = 0.001
R11	R13	0.634	p = 0.003

In Hindlimb, the dorsal surface of the lateral hoof (R2) had a high correlation with the dorsal surface of the medial hoof (R4) (R=0.913) and the dorsal surface of the interdigital area (R6) (R=0.888). Similarly, a high correlation was observed between the temperature of the dorsal surface of the medial hoof (R4) and the temperature of the interdigital dorsal surface (R6) (R=0.887). The posterior surface of the interdigital area (R8) had a high correlation with the medial heel (R12) (R=0.913) and between the dew claws (R14) (R=0.839), a moderate correlation with the dorsal surface of the lateral hoof (R2) (R=0.584) and the dorsal surface of the interdigital area (R6) (R=0.680). A high correlation was observed between the temperature of the lateral heel (R10) and the temperature of the posterior interdigital surface of the hoof (R8) (R=0.965).

Lastly, a moderate correlation was observed between the temperature between the dew claws (R14) and the medial heel (R12) (R=0.747). Correlation coefficients for the Hindlimb are shown in Table 4.

Table 4. Hindlimb correlations

Anatomical Location 1	Anatomical Location 2	Correlation coefficient	P value
R2	R4	0.913	p < 0.01
R2	R6	0.888	p < 0.01
R4	R6	0.887	p < 0.01
R8	R12	0.913	p < 0.001
R8	R14	0.839	p < 0.001
R8	R2	0.584	p = 0.007
R8	R6	0.680	p = 0.001
R10	R8	0.965	p < 0.001
R14	R12	0.747	p < 0.001

DISCUSSION AND CONCLUSION

The use of infrared thermography to identify lameness and foot lesions in cattle has increased due to its non-invasiveness and cost reduction. However, these studies were conducted by correlating thermographic data with the disease when it progressed and manifested in lameness. Thermographic temperatures rise considerably in conditions that cause lameness (9). The present study used thermographic images with lameness scoring to identify tissues with increased temperature before clinical symptoms appeared. The relationship between lameness scoring and thermography was also examined. We found no significant correlation between scoring and temperatures. This result may be affected by the low scores of the cattle in the study. Low scores are also due to the absence of apparent symptoms of foot disease. However, as mentioned earlier, it is necessary to identify temperature increases and take appropriate measures before clinical symptoms appear. At this point, the importance of including thermography in the scoring becomes apparent.

When scoring lameness, the observer's experience and method are important. Danscher et al. (12) showed that movement scores obtained by live observation differed from those obtained by filming and reported that fine movements could be verified by video recording when performing multiple assessments. Therefore, in our study, video recordings were taken during lameness scoring and then evaluated by two observers. Factors such as differences in how cows walk, udder size, age, and environment can be ignored when scoring lameness (13), and scoring may not be effective in the early stages of diseases. However, clinical examination and other diagnostic methods, such as thermography, may be more effective. Infrared thermography is a non-invasive method for early detection of lesions before the appearance of clinical symptoms (14). When comparing anatomical regions, a 1 °C or more difference may indicate a possible pathology (15). Although the number of subjects in our study was small, thermographic measurements were made from different points (a total of 280 anatomical regions) on the feet of cows to determine the temperature differences, as stated in the reference above.

Stokes et al. (16) reported that the temperature threshold for dirty feet is 27°C. When this parameter was evaluated, four animals with a lameness score of 1, i.e., considered normal, had a temperature above 27°C at least one point. Even in 10 anatomical regions of animal 3, temperatures above 27°C were detected. Conversely, an animal with a lameness score of 3, i.e., considered moderately lame, does not exceed 27°C in any anatomical region. More subjects are needed to evaluate the parameter as a threshold for early lameness detection and compare it with scoring. To make such a comparison, many animals must be scored for lameness and temperature measurements from many anatomical sites.

Studies have reported that most lameness originates from the hindfoot, especially the lateral hoof (17-19). Muray et al. (18) even reported a lesion rate of 65% in the lateral hoof of the Hindlimb. Our study found no significant difference between the temperature values obtained from the forelimbs and hindlimbs. However, the highest value was 3 in the scored animals. In the case of severely lame animals, i.e., animals with a score of 4 or 5 were identified and included in the study, we think that the temperature differences detected from the forelimbs and hindlimbs would be revealed.

Alsaaod and Buscher (9) found that mean skin temperatures for healthy hoof ranged between 29.9-32.1°C when considered within an ambient temperature of 20.3°C. We noted that the ambient temperature was 25°C during the thermographic measurements. When skin temperatures were evaluated under these conditions, it was determined that the temperatures ranged between 14-33.30°C, although they were higher than the ambient temperature stated in the literature. It may not be correct to give a precise temperature value for healthy feet based on the possibility that thermographically measured temperatures may be affected by many other factors, not only the ambient temperature. The feet measured in our study were not dirty. Any waste on the foot can change the temperature. Therefore, many factors must be examined and eliminated to give an average value for healthy feet.

Stokes et al. (16) reported that the mean plantar temperature of dirty-footed animals without lesions was 22.2°C. In the present study, the temperature was measured at R8, R10, R12, and R14 on the plantar aspect of the hindlimbs. The average of the measurements taken from R8 was 20.14°C (12,30-28,80°C). The average was 20.10°C at R12 (12-33.30°C), 20.06°C at R10 (12.70-30.40°C) and 19.30°C at R14(12.60-28.20°C).

In their study, Stokes et al. (16) only reported the temperature on the plantar aspect of the feet without specifying the anatomical region. Our study measured temperature at 4 points on the plantar surface. Even if these temperatures are averaged, they are lower than the temperature reported by Stokes et al. (16). Moreover, a lower temperature was found even though the feet we measured were clean. Therefore, different measurements should be taken by detailing the anatomical regions in the studies.

The results of Alsaaod and Buscher (9) showed an increase in the surface temperature of the coronary band of the affected foot compared to the healthy contralateral foot. When determining coronary band temperatures, we took measurements from both the medial and lateral hoof. When the measures taken from the right and left (forelimb-hindlimb) feet were evaluated in general, the coronary band temperatures ranged between 13.30-29.20°C, the interdigital dorsal surface 14.40-31.90°C, the lateral and medial heel 12.70-33.30°C and the between the dew claw 12.60-28.20°C. In this case, making comparisons between regions may not be very accurate. Still, we believe that it would be more accurate to make thermographic measurements to determine which area is most exposed to temperature increases in diagnosed foot diseases.

In their literature research, the authors found that lateral hoofs were warmer in hindlimbs (20,21), while there was no difference between medial and lateral hoofs in forelimbs (9,20). Our study found a high correlation between the dorsal surface and the dorsal surface of the medial hoof and the dorsal surface of the interdigital region. However, higher temperatures were not found in the lateral hoof of the hindlimbs. Instead of separating the medial and lateral hoof, we saw a diffuse temperature increase on the dorsal surface of the area. Comparisons between affected and healthy contralateral anatomical structures on multiple scan images help define the consistency of an abnormality (9,15,21). Instead of detecting increased temperature after the onset of diseases, it would be better to measure it before clinical signs appear and compare it with other methods, such as lameness scoring. Thermography may have great potential in the early diagnosis of foot diseases. Taking non-invasive and accurate measurements in multiple animals in rapid succession (9,22) is one of the advantages we have seen in our study.

In conclusion, although no disease was diagnosed in our study, high temperatures were determined at some anatomical points. We think that these regions should be followed up by examining them later. Because thermography may indicate damaged tissue. In this way, measures can be taken in the early period, contributing to both the enterprise's economy and the animals' welfare. Since lameness scoring alone may be insufficient before lameness progresses, we think thermography can be a guide. In addition, thermography may be advantageous in preventing loss of productivity or economic costs due to early diagnosis of diseases that cause lameness.

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CONFLICT OF INTEREST

There is no conflict of interest to be declared by the authors.

AUTHOR CONTRIBUTIONS

Elif Dogan, Mumin Gokhan Senocak and Ayse Basak Kapcak were involved in the original study design. All three authors wrote and revised the manuscript. Data analysis/interpretation: Elif Dogan, Mumin Gokhan Senocak. Statistical analysis, manuscript drafting, and literature research: all authors. All authors have critically revised and approved the final version of the manuscript.

ETHICAL STATEMENT

The authors confirm that the ethical policies of the journal, as noted on the journal's author guidelines page, have been adhered to. 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).

REFERENCES

1. **Cook NB, Rieman J, Gomez A, Burgi K (2012).** Observation on the design and use of footbaths to control infectious hoof disease in dairy cattle. *Vet J.*, 193:669-673.
2. **García-Munoz A, Singh N, Leonardi C, Silva-Del-Rio N (2017).** Effect of hoof trimmer intervention in moderately lame cows on lameness progression and milk yield. *J Dairy Sci.*, 100:9205-9214.

3. **Alsaaod M, Schaeffer AL, Buscher W, Steiner A (2015).** The role of infrared thermography as a non-invasive tool for the detection of lameness in cattle. *Sensors.*, 15:14513-14525.
4. **Archer S, Bell N, Huxley J (2010).** Lameness in UK dairy cows: A review of the current status. *In Practice*., 32:492-502.
5. **Schlageter-Tello A, Van Hertem T, Bokkers EAM, Viazzi S, Bahr C, Lokhorst K (2018).** Performance of human observers and an automatic 3-dimensional computervision- based locomotion scoring method to detect lameness and hoof lesions in dairy cows. *J Dairy Sci.*, 101:6322-6335.
6. **Flower FC, Weary DM (2006).** Effect of hoof pathologies on subjective assessments of dairy cow gait. *J Dairy Sci.*, 89:139-146.
7. **Bobić T, Mijić P, Gregić M, Bagarıć A, Gantner V (2017**). Early detection of the hoof diseases in holstein cows using thermovision camera. *Agric Conspec Sci.*, 82:197-200.
8. **Westermann S, Buchner HHF, Schramel JP, Tichy A, Stanek C (2013).** Effects of infrared camera angle and distance on measurement and reproducibility of thermographically determined temperatures of the distolateral aspects of the forelimbs in horses. *JAVMA*., 242:388-395.
9. **Alsaaod M, Büscher W (2012).** Detection of hoof lesions using digital infrared thermography in dairy cows. *J Dairy Sci*. 95:735-742.
10. **Sprecher DJ, Hostetler DE, Kaneene JB (1997).** A Lameness scoring system that uses posture and gait to predict dairy cattle reproductive performance. *Theriogenology*, 47 (6):1179-1187.
11. **Pezeshki A, Stordeur P, Wallemacq H, et al. (2011).** Variation of inflammatory dynamics and mediators in primiparous cows after intramammary challenge with *Escherichia Coli*. *Vet Res.*, 42:1-10.
12. **Danscher AM, Enemark JMD, Telezhenko E, Capion N, Ekstrøm CT, Thoefner MB (2009).** Oligofructose overload induces lameness in cattle. *J Dairy Sci.*, 92:607-616.
13. **Viazzi S, Bahr C, Schlageter-Tello A, et al. (2013).** Analyse individual classification of lameness using automatic measurement of back posture in dairy cattle. *J Dairy Sci.*, 96:257-266.
14. **LokeshBabu DS, Jeyakumar S, Vasant PJ, et al. (2018).** Monitoring foot surface temperature using infrared thermal imaging for assessment of hoof health status in cattle: A review. *J Therm Biol*., 78:10-21.
15. **Turner TA (1991).** Thermography as an aid to the clinical lameness evaluation. *Vet Clin N Am Equine Pract.*, 7:311-338.
16. **Stokes JE, Leach KA, Main DCJ, Whay HR (2012).** An investigation into the use of infrared thermography (IRT) as a rapid diagnostic tool for foot lesions in dairy cattle. *Vet J.*, 193:674-678.
17. **Lawrence KE, Chesterton RN, Laven RA (2011)**. Further investigation of lameness in cows at pasture: An analysis of the lesions found in, and some possible risk factors associated with, lame New Zealand dairy cattle requiring veterinary treatment. *J Dairy Sci.*, 94:2794-2805.
18. **Murray RD, Downham DY, Clarkson MJ, et al. (1996).** Epidemiology of lameness in dairy cattle: Description and analysis of foot lesions. *Vet Rec.*, 138:586-591.
19. **McLennan MW (1988).** Incidence of lameness requiring veterinary treatment in dairy cattle in Queensland. *Aust Vet J.*, 65(5):144-147.
20. **Nikkhah A, Plaizier JC, Einarson MS, Berry RJ, Scott SL, Kennedy AD (2005).** Short communication: Infrared thermography and visual examination of hooves of dairy cows in two stages of lactation. *J Dairy Sci.*, 88:2749-2753.
21. **Cockcroft PD, Henson FM, Parker C (2000).** Thermography of a septic metatarsophalangeal joint in a heifer. *Vet Rec.*, 146:258-260.
22. **Eddy AL, van Hoogmoed LM, Snyder JR. (2001).** The role of thermography in the management of equine lameness. *Vet J.,* 162:172-181.