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THE VALUE OF A COMBINED DRUG AND LASER THERAPY PROTOCOL IN LAMENESS MONITORED WITH THERMOGRAPHIC MEANS – A CLINICAL STUDY IN 20 HORSES

IMPORTANȚA UNUI PROTOCOL COMBINAT DE TERAPIE ALOPATĂ ȘI LASER ÎN ȘCHIOPĂTURĂ MONITORIZAT PRIN MIJLOACE TERMOGRAFICE - STUDIU CLINIC PE 20 DE CAI

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ABSTRACT | REZUMAT

In the study were included (n=20) horses: Group 1, with lesions of carpal/tarsal joint and metacarpal/ metatarsus phalange joint and Group 2, clinically healthy). The equipment used was a FLIR B200 Western thermal imager (Extech Instruments, Boston, USA) and a Laser Bio Medical Systems MultiProg 2510 (Bio-Medical-Systems, Wiesbaden, Germany), the images being processed with FLIR Tools version 5.13.18031. 2002; FLIR Systems 2015 (Extech Instruments, Boston, USA). Statistical analysis-paired Student's *t*-Test was used. The horses in Group 1, undergoing drug therapy (meloxicam) and laser-therapy, were clinically examined; afterward, thermal images were taken in the caudal-cranial direction. The position of the camera: for the front limbs an angle of 150° with imaging from the lateral right and left and, respectively, for the hind limbs, a 180° angle was adopted. Thermographic imaging can help interpret clinical symptoms and localize tendon injuries. The applied treatment scheme showed a significant reduction in clinical signs and temperature difference between the affected limb and the contra lateral one. Laser therapy as an adjuvant of allopathic therapy helped reduce drug dosage and administration period. We propose thermal imaging as a supportive investigation methodology in a clinical setting and laser therapy as a supplementary treatment method in horses.

Keywords: horse, lameness, laser therapy, thermography

În studiu au fost incluși (n=20) cai: Grupul 1, caii prezentau leziuni ale articulației carpiene/tarsiene și ale articulației falangei metacarpiene / metatarsiene și Grupul 2, Control, cai clinic sănătoși. Echipamentul folosit a fost un termograf FLIR B200 Western (Extech Instruments, Boston, SUA) și un Laser Bio Medical Systems MultiProg 2510 (Bio-Medical-Systems, Wiesbaden, Germania), imaginile fiind procesate cu FLIR Tools (versiunea 5.13.18031.2002), FLIR Systems 2015 (Extech Instruments, Boston, SUA). Analiza statistică asociată testului a fost testul *t*- Student. Caii din Grupul 1, au fost supuși terapiei medicamentoase (meloxicam) și terapiei cu laser, și au fost examinați clinic; ulterior au fost realizate imagini termice în direcția caudal-cranianã. Poziția camerei: pentru membrele frontale a adoptat un unghi de 150° cu imagistica din lateral dreapta și stânga și, respectiv, pentru membrele posterioare, un unghi de 180°. Termografia poate ajuta la interpretarea simptomelor clinice și la localizarea leziunilor tendinoase. Schema de tratament aplicată în acest caz a relevat reducerea semnificativă a simptomelor clinice și a diferenței de temperatură (între membrul afectat și cel lateral) date confirmate statistic. Terapia cu laser ca adjuvant al terapiei alopate a contribuit la reducerea dozei de medicament și a perioadei de administrare. Propunem imagistica termică ca metodă de investigație de susținere într-un cadru clinic și terapia cu laser ca metodă suplimentară de tratament la cai.

Cuvinte cheie: cal, șchiopătură, terapia cu laser, termografie

The welfare of animals in general and, of dogs and horses in particular, has become more important in the last decades especially, due to sports and leisure activities, where members' acute and chronic pain is common. Therefore, it became important to use and apply more suitable, new diagnostic modalities, which are less invasive than traditional ones (13). In this aim, thermographic imaging is a non-invasive diagnostic modality that helps clinicians to better interpret pain in animals. Thermography is a useful tool for establishing diagnose of lameness in horses and for monitoring purposes. Medical conditions that can be diagnosed are tendonitis and laminitis, inflammation in the joints and abscesses. Also, infrared cameras can highlight the beneficent effect of laser therapy in horses (4, 6).

Thermography is also used to evaluate the effec-

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tiveness of physical therapy measures in the horse and it is a useful predictive technique when studying the metacarpal changes in racehorses, which can indicate lesions before clinical signs appear (7, 17).

Infrared cameras use electromagnetic radiation to detect changes in surface temperature. As temperature changes also the infrared radiation suffers modification and can be detected by the change of colour in the thermographic image (10). The changes are registered by the infrared camera with barium-strontium titanate (BST) and transformed into electronic signals that can be processed by software (7).

The obtained thermogram is the mirror of the variation of electromagnetic emissions. Generally, the thermogram is colored white for the highest emission and black for the lowest (11).

The therapy with infrared radiation can be used for cells and tissues. Effects on biological activity can be generated with electromagnetic radiation in the form of infrared radiation with a wavelength of 780–100.000 nm (23). Thermal imaging has no use in chronic cases of lameness in horses. It is a diagnostic method for early-stage disease, where temperature differences are more likely to be detected. Here, palpation, which is the most used method, fails to detect temperature changes of approximately 1°C (5).

Also, thermography should not be used in cases of deep lesions. Thermography can be initiated as early as 45 min. after intensive exercise, to deliver reliable information and uninfluenced by thermoregulatory mechanisms (12). It can be stated that thermography is rather a physiological analysis of the inflammation process than an anatomical one (2, 6, 24). The newest investigations had shown that it is highly recommended to use an exact protocol and a controlled environment to avoid errors of interpretation of the thermal image (22). Sunlight and humidity can affect the quality of the thermographic image and, if the study is conducted outdoor, it is advisable to select a threshold temperature. Three fixed points of temperature measurement resulted in an acceptable threshold temperature (18, 19). After some authors, the best outdoor temperature ascertained for thermal imaging is 20°C (6, 25).

It is also important to evaluate the asymmetric change of temperature by comparison of the right and left leg. Afterward, the exact temperature changes should be taken into consideration to establish a threshold temperature. The detection of pathological modification with the help of a thermogram is possible in the horse when the temperature is elevated with at least 1.25°C (21).

Between species, in dairy cows, the maximum temperature was the most relevant indicator of lameness, but other statistical indicators also mentioned lameness compared to healthy feet (12). Still, artifacts are difficult to exclude and the clinical significance of thermographic modification remains difficult to prove in some cases (14).

Recently, the treatment of chronic and acute pain in horses has become a more important aspect for veterinarians to be considered. Physical therapy alone, or with drug treatment, has proven to be an excellent alternative to allopathic treatment by itself. Especially, the long-term effects of physiotherapy are to be taken into consideration. In this aim this current *initio* study has verified the effectiveness of a drug and physiotherapy combination by using thermography.

MATERIALS AND METHODS

Animals

In the study, there were included (n=20) horses, with ages ranging from 5 to 25 years and weight between 300 and 600 kg, whose owners have agreed and consented to participate in this experiment. The owners have been previously informed about the therapeutic and recovery protocol used, which fits the veterinary methods used in practice. From the subjects observed nine horses were diagnosed with digital flexor tendonitis and one case was diagnosed with a carpal collateral ligament injury.

Table 1

Horses included in the study

No.	Breed	Age (years)	Sex
1.	American Quarter Horse	5	Mare
2.	American Quarter Horse	20	Mare
3.	American Quarter Horse	5	Mare
4.	American Quarter Horse	17	Mare
5.	Arabian horse	11	Gelding
6.	American Quarter Horse	18	Mare
7.	American Quarter Horse	13	Mare
8.	American Quarter Horse	16	Gelding
9.	American Quarter Horse	18	Mare
10.	Arabian horse	11	Gelding
11.	Bavarian Warmblood	25	Gelding
12.	Bavarian Warmblood	10	Mare
13.	Arabian horse	25	Mare
14.	Arabian horse	22	Gelding
15.	Arabian horse	16	Mare
16.	Arabian horse	23	Gelding
17.	Icelandic Horse Mix	13	Gelding
18.	Mixed breed	19	Mare
19.	American Quarter Horse	11	Mare
20.	American Quarter Horse	13	Mare

All these (n=10) patients, with lesions were in the region between the carpal/ tarsal joint and metacarpal / metatarsus phalange joint, were included in Group 1 and (n=10) horses, clinically diagnosed as healthy were included in Group 2. This *initio*-clinical study was conducted under field clinical settings, so the environmental temperature cannot be controlled being one idea to follow. In Table 1, the breed, age and sex of the horses included in the study are presented.

Used equipment and technique

The technical equipment used was a FLIR B200

Table 2

Horses with injuries included in Group 1

Breed	Clinical findings	Clinically assumed diagnosis	Treatment scheme
Bavarian Warmblood	acute left forelimb lameness, carpal joint swelling, pressure sensitive on the medial side, warm region by palpation	Carpal collateral ligament injury	**Rivanol bandage** Rivanol 1g powder (Dermapharm AG, Germany), solved in 1-L water and poured on absorbent cotton bandage Time: 2 days. **Meloxicam** 1st day: Melosolute, (CP Pharma, Germany), 20 mg/mL, i.v.; 0.6 mg Meloxicam/kgbw, (i.e. 3 mL/100kg). 2nd to 5th day: Melosus Pferd, (CP Pharma), 15mg/mL suspension 15mg/25kg (i.e. 1mL/25 kg) p.o., Time: 5 days. **Laser therapy** Nogier laser frequencies 3 times: 1). Fr.A: 5 min. 2). Fr.B: 5 min. 3). Fr.C: 5 min. Time: 4 days (15)
Bavarian Warmblood	Acute left forelimb lameness, distal limb swelling, flexor tendon pressure sensitive, warm in the region	Superficial/deep digital flexor tendonitis	
Arabian	Acute left forelimb lameness, distal limb swelling, flexor tendon pressure sensitive, warm in the region	Superficial/deep digital flexor tendonitis	
Arabian	Acute right forelimb lameness, distal limb swelling, flexor tendon pressure sensitive, warm in the region	Superficial/deep digital flexor tendonitis	
Arabian	acute left hindlimb lameness, swelling of the distal limb, flexor tendon pressure sensitive, warm in the region	Superficial/deep digital flexor tendonitis	
Arabian	acute lameness of the left hindlimb, no evident swelling, flexor tendon pressure sensitive, no perceptible temperature increase	Superficial/deep digital flexor tendonitis	
Icelandic Mix	acute right hind limb lameness, distal limb swelling, flexor tendon pressure sensitive, warm in the region	Superficial/deep digital flexor tendonitis	
Mixed breed	Acute left forelimb lameness, distal limb swelling, flexor tendon pressure sensitive, warm in the region	Superficial/deep digital flexor tendonitis	
American Quarter	acute right hind limb lameness, distal limb swelling, flexor tendon pressure sensitive, warm in the region	Superficial/deep digital flexor tendonitis	
American Quarter	acute right hind limb lameness, distal limb swelling, flexor tendon pressure sensitive, no perceptible temperature increase	Superficial/deep digital flexor tendonitis	

Western thermal imager (Extech Instruments, Boston, USA) and a Laser Bio Medical Systems MultiProg 2510 (Bio-Medical-Systems, Wiesbaden, Germany), the obtained images being processed with FLIR Tools version 5.13.18031.2002; FLIR Systems 2015 (Extech Instruments, Boston, USA).

The horses in Group 1, undergoing drug therapy and laser-therapy, were clinically examined; afterward, thermal images were taken in the caudal-cranial direction. To obtain the most unambiguous image we standardized the position of the camera: for the front limbs an angle of 150° was adopted with imaging from the lateral right and left and, respectively, for the hind limbs, a 180° angle was adopted.

Always symmetrical images of the injured and the contra lateral limb were taken (Fig. 1).

The horses in Group 2 were healthy, and the clinical examination, respectively, the thermal imaging protocols were identical to those from Group 1. All horses were photographed two times: initially at the first examination and then, 14 days afterward and minimum and maximum temperature was shown by the FLIR software. The same region was then examined in the contra lateral limb and the difference between the two averages was determined (Table 3).

In Group 2, the images of healthy horses were also taken at 14 days interval, the same calculation model for the forelimb and the hind-limb respectively being used. Then, the average between the forelimb values and the hind-limb values of each healthy horse were calculated (Table 4).

Statistical analysis

We used Student's *t*-Test two Paired samples for means because we compared paired average temperature differences temperature values between the first and second examinations. Also, the average temperature of the analysed regions was determined.

The injuries clinically observed were all, located between the carpal/tarsal joint and metacarpal / metatarsal-phalange joint, the treatment method in our study is the same for both injuries, superficial and deep digital flexor tendonitis, as recommended also by other authors in this field (15, 20). The distance be-

tween the camera and limb was 100 cm, afterward; the video-material of the horse was filmed in walk and trot. The clinical findings and the recuperative scheme for horses in Group 1 are shown in Table 2.

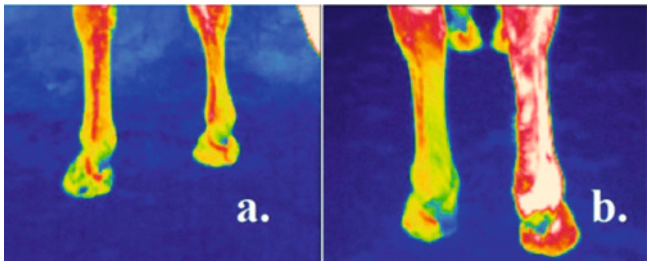

Fig. 1. Thermal images of the forelimbs in 150° angle (a) and of the hind-limbs in 180° angle (b)

Table 3

Group 1 - Difference between the two average values of ˚C at the first and second examination

No.	Values/Average between forelimb and hind-limb values		
	The first examination	The second examination	First vs. Second
1.	1.90	0.50	1,4
2.	5.40	1.80	3,6
3.	5.10	1.80	3,3
4.	2.20	0.70	1,5
5.	1.60	0.10	1,5
6.	1.90	0.30	1,6
7.	1.00	0.50	0,5
8.	4.00	0.20	3,8
9.	1.70	2.90	1,2
10.	2.40	0.70	1,7

Table 4

Group 2 - Difference between the two average values of ˚C at the first and second examination

No.	Group 2		
	Values/Average between forelimb and hind-limb values		
	The first examination	The second examination	First vs. Second
1.	0.40	0.10	0,3
2.	0.15	0.35	0,2
3.	0.25	0.40	0,15
4.	0.25	0.35	0,1
5.	0.60	0.45	0,15
6.	0.45	0.25	0,2
7.	0.10	0.90	0,8
8.	0.60	0.45	0,15
9.	0.50	0.40	0,1
10.	0.25	0.50	0,25

RESULTS AND DISCUSSION

Figure 2 shows the difference between the average temperature of the injured area and the healthy contra lateral area of the injured horses (Group 1) at the 1st and 2nd examination.

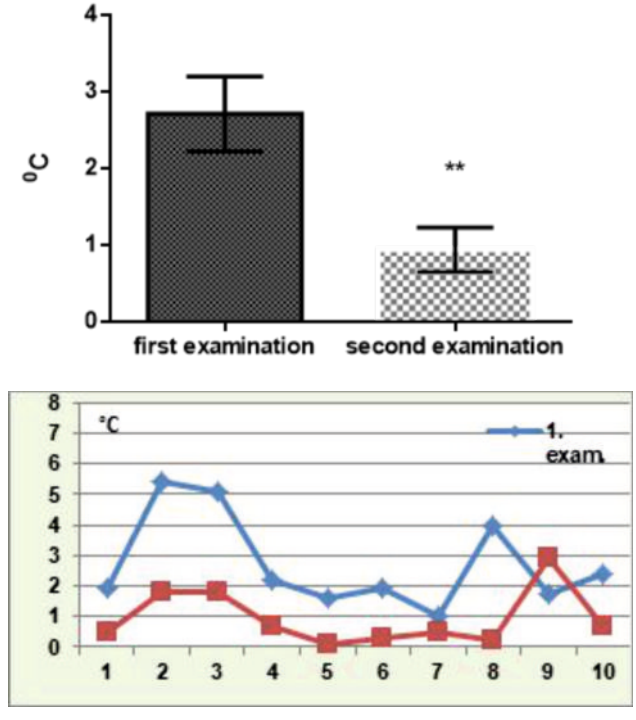

Fig. 2. Group 1 - Temperature differences between injured limb and healthy contra-lateral limb of injured horses at the first and second examinations (significant difference =** $p<0.01$)

In Figure 3, it is shown the calculated (°C) average values of all limbs measured at the first and second examination for Group 2.

As it is shown above it is visible that the temperature difference between the affected and healthy contra lateral limbs in Group 1 horses was greater when compared to those of Group 2. The temperature differences in the first examination of the injured horses are equal or above 1.5°C in all horses but horse 7. In horse 9, the value in the second examination was even higher than in the first examination. In the case of this horse, the strict stable rest was not followed and the treatment protocol was prolonged.

The obtained temperature differences between the affected and the contra lateral limbs (value 1, Group 1), were greater than 1.25°C in 9 of the 10 examined horses. We consider this modification as a thermographic indication of inflammation. Clinical assessment of the horse with a temperature difference under 1.25°C indicated pain in the examined area, the second value after therapy was reduced to half. In the second examination series, there were 2 values greater than 1.25°C, but when compared to the initial value there was a significant reduction in inflammation both, clinically and thermographically.

After initiating a paired t-test in Excel 2010 with the values of the horses in Group 1, we obtained a p-value of p <0.01, showing a significant difference between the first and the second examination of the horses in Group 1. In Group 2, the absolute average value of the temperature differences in all limbs ranged from 0.1°C to 0.8°C, being visible that the values of the first and second examination of the horses included in Group 2 had a lower degree of variance.

To be able to compare Groups 1 and 2, the absolute values of the obtained difference average were statistically ascertained, revealing a highly significant difference ($^{***}p$ <0.001) between results obtained, confirming the logic of this study (Fig. 4).

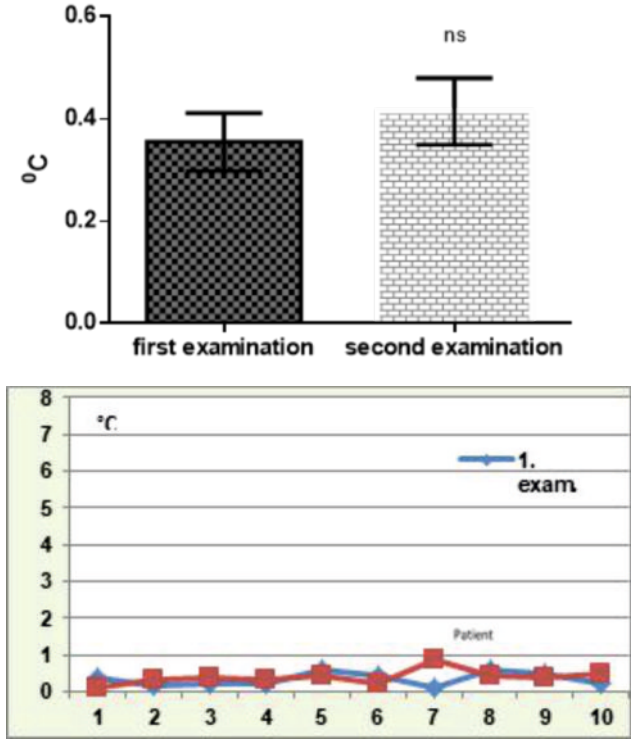

Fig. 3. Group 2 - Average values in °C of all limbs measured at the first and second examination (*ns* = not significant, p>0.05)

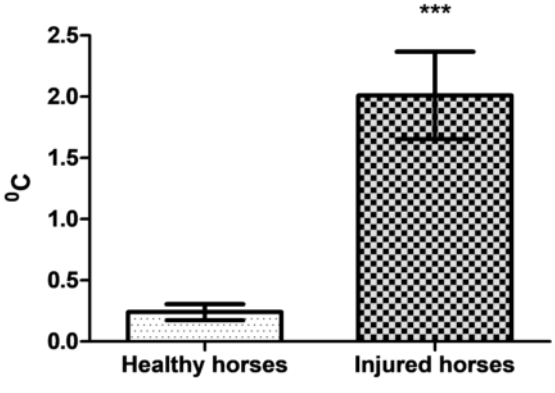

Fig. 4. The absolute values of all limbs measured comparatively in Group 2 (healthy) and Group 1 (injured) (highly significant difference = $^{***}p$<0.001)

When comparing the values for Groups 1 vs. 2, we ascertained a p-value of p <0.001, indicating a highly significant difference between the healthy vs. injured horses, confirming that the usage of temperature differences between affected and contra-lateral regions is recommended. This is because it is more independent from surrounding temperature and a significant correlation for tendinopathies was demonstrated (21, 26). We agree that in field conditions examination, the wind velocity can influence the distal limb temperature and, this is why the recommendation to perform thermography in a controlled environment is fully reasonable, even though for clinicians this is sometimes difficult. To avoid the major influence of wind on temperature differences, we always used the relationship between the affected limb and the contra lateral limbs (28). Although some authors proposed that the best surrounding temperature for thermography has to be between 20 and 25°C, in the case of horses, and in our study, they acclimatized, as recommended, to the environment temperature of 2–7°C for 15 minutes, afterwards the images were taken (1).

Since the study was conducted in winter in clinical conditions we couldn't respect this indication, but also it is important to emphasize that in cold seasons the injuries are much more frequent also and thermography can be used for therapeutic monitoring of lameness in horses. In competition with up mentioned, the great advantage of using thermography is that the clinician can verify if there is an inflammation associated with the sensitivity palpated and it is a good comparison method of temperature change before and after inflammation (3).

We agree that hair length influences the thermogram and therefore a uniform length is quite favourable for this method's accurate result (9).

Our study also monitored the efficiency of laser-therapy and allopathic drug combinations in horses with lameness. At this point, we agree that thermography act like a mirror of vascularization and therefore in can be used to evaluate the evolution of flaps and grafts on patients who underwent reconstructive surgery and then received laser therapy (8).

The proposal for laser therapy dosage was highlighted earliest from a fine study by Petermann (2016), who applied only laser-therapy on 30 horses with acute and chronic tendonitis and obtained really promising results after the clinical and sonographic examination (16).

The centre of weight in horses is closer to the forelimbs. In a study by Weishaupt (2004) an injured leg with lameness bears fewer loads than the other 3 healthy limbs and the load is repositioned. If for example, the left forelimb suffers from lameness, the vertical load will reduce in this leg and the right hind-limb, in return the right forelimb and left hind-limb will bear a more vertical load. This will influence the blood flow in the intensively used limbs, which will influence the thermogram (27).

To avoid this deviation in temperature, we compared in Group 1 only the injured and the contra lateral

limb. In Group 2 we compared all 4 limbs to obtain the average temperature difference because weight-bearing is not modified in healthy horses. These values were then used to compare Group 1 and Group 2 values with concluding statistical results.

CONCLUSIONS

Thermographic imaging can help interpret clinical symptoms and localize tendon injuries in horses. The treatment scheme used illustrated a significant reduction of clinical signs and temperature difference between the affected limb and the contra lateral limbs.

Laser therapy as an adjuvant of allopathic therapy helped reduce the drug dosage and administration period in the observed horses.

This type of combined therapy shows promising progress in the healing process of lameness in horses and, further studies should be conducted in this field.

Even though, we propose thermal imaging as a supportive investigation methodology and a supplementary associated treatment in horses.

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