THERMOGRAPHY IN HORSES

A added value for osteopaths?

Abstract

The objective of this paper is to assess the questions if the usage of thermography is an added value to osteopaths. And if so, what is its role in diagnostic enhancement, early detection and prevention of lesions and treatment monitoring in equine patients

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Is thermography an added value to Osteopaths?

Osteopaths have the mission to try to detect any functional disturbances as early as possible. In the light of the foundational principles by A. Still, an osteopathic intervention aims to address the self-healing and regulating mechanisms of the patient as much as possible. Although the hands of the osteopath are the primary and most important tool to assess the patient, could there be any additional tools to help achieve this goal?

Background information of thermography

Medical Infrared Thermography (MIT) is based on the recording of infrared radiation emitted by the skin and superficial tissues. Heat is continuously produced by the body and released through the skin by radiation, convection, conduction or evaporation. The skin's temperature is influenced mainly by local circulation and tissue metabolism. As tissue metabolism is fairly stable, differences in skin temperature are largely caused by changes in local tissue perfusion. The efficiency of a surface in emitting infrared radiation is called emissivity, which has in ideal circumstances a value of 1. With an emissivity of 0.98-1.0 , this makes skin and hair coat very efficient infrared radiators.

Body temperature is subject to circadian fluctuations and this variation is caused by several factors, like physical activity, stress, climatological conditions, inflammation and the presence of an infectious process. For example, skin overlaying large muscles will increase in temperature due to muscle activity. A significant increase in average temperature is measured with muscle size and exercise intensity being the most determining factors. Moreover, 75-80% of all produced energy by a muscle is converted into heat, while the remaining 20-25% goes to mechanical energy (5,7,13,18).

Local microcirculation is directly controlled by the autonomous nervous system (ANS) trough vasodilatation and vasoconstriction, so MIT unfolds itself as a window to the integrity of the vasomotor component of the ANS. Changes in body surface temperature may indicate inflammatory, vascular, or neurological disorders. It will typically display these disorders as an area of increased surface temperature (hot spots) (5,13). In contrast, cold spots can give the practitioner an idea of the longevity of the problem. Although this is contradicted by some authors, who believe only hot spots are indicative for pain. An increased sympathetic activity in the lateral horn will create vasoconstriction resulting in segmental strips of cooling. When scanning lower limbs or feet this can show up as an immense cooling area (20).

Thermography has proven to be a useful tool in several human medicinal fields like the assessment of the quality of anesthesia blocks , pain monitoring in epidural blocks and a complementing tool to evaluate pain based on facial expressions. In surgery it has proven its usefulness in the monitoring of vascular perfusion in surgical flaps and bone vascularization status in dental implants. The significant correlation between pain -indices and MIT justifies it's usage for evaluating pain in anesthetized patients or those under critical care (5).

In veterinary medicine, it has been used to evaluate animal welfare, detect lesions, and in surgical procedures. When assessing superficial body temperature, as part of an osteopathic evaluation, changes between different body parts on both sides of the horse are evaluated manually. This detection method is subject to inter-person variation and often not sufficient to detect subtle temperature differences. Moreover, thermography is at least 10 times more sensitive than palpation in detecting changes in skin temperature. In fact, in an MIT evaluation process a temperature difference of >1°C between the areas of interest is considered abnormal. In chronic cases, there is a possibility of non-detection by MIT of any temperature difference and therefore it's usability in chronical cases is contradicted in several studies (5, 10, 13).

It's measurements are however prone to artifacts, and this has led to some doubts on its repeatability, sensitivity and clinical usage. These include external sources like ambient temperature above 30°C where heat loss from sweating occurs, excessive hair with non-uniform length, dirt ,leg wraps, blankets, scar tissue etc.… Ideally, MIT should be performed under controlled ambient temperature in the range of 20°C. The measurements are however not influenced by the position of the infrared camera (5, 10, 19).

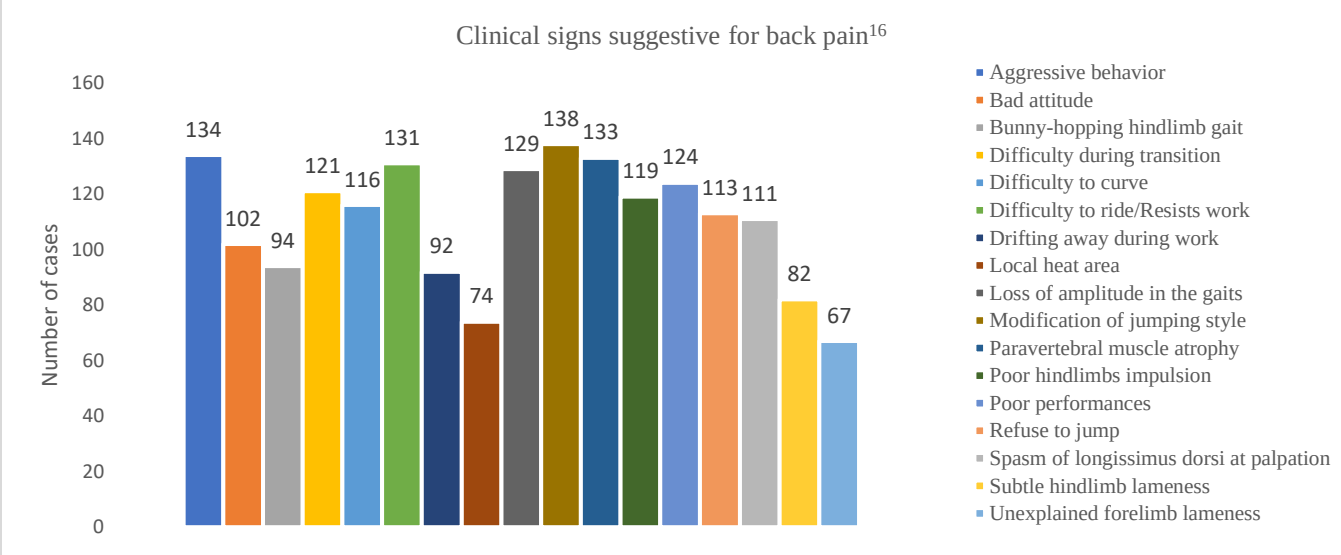
Role of thermography in the osteopathic diagnostic process

Welfare issues in the equestrian sport call for an early and effective detection of gait abnormalities or lameness to prevent injuries and chronic discomfort when ridden.

One of these common abnormalities frequently seen in equine patients is back pain. It's origin may be related to soft tissue, vertebral injuries, neurological disorders or any problems with saddle or tack. Back pain is common in ridden horses, it is estimated to affect more than 47% of sport horses (1). Various back pathologies have been linked to different equine disciplines. Jumping horses at speed are more prone to acute sacroiliac strain, showjumpers show mostly

over-riding dorsal spinous processes. Back pain affected school and leisure horses twice as much compared to other working horses (13).

In a multicenter survey over 10 years, 70% of the veterinary respondents said to diagnose back problems in between 0-20% of the orthopedic cases seen. Based on their answers, a list of clinical signs was created suggestive for back pain. The most frequently used diagnostic methods in this survey was radiography and ultrasonography. Inaccessibility of the region and a wide variation of pain manifestations where found to be one of the most challenging factors in the diagnostic process. Thermography was seldom used (88% of respondents) and 30% of users fount it unreliable (16).



Therefore, many injuries remain undiagnosed or have a delay in diagnosis, as radiography of the equine spine is difficult or may require general anesthesia. Thermography as an complementary diagnostic tool can offer an advantage here. Like scintigraphy, these methods are physiologic imaging modalities, providing information on the circulation and tissue physiology. While scintigraphy can be used to evaluate osseous process, MIT images can evaluate soft tissues and possibly inflammation, usually a cause of pain. It can be used as a screening method to determine if referral to anatomical imaging modalities like radiography and echography is warranted to determine the size and shape and nature of the problem. Moreover, most radiographic changes in bone are only visible 10-14 days after the event and changes cannot be directly correlated with the clinical signs. The corresponding MIT image can help in the determination if the radiographic changes seen are indeed associated with inflammation, and thus the probable cause of the clinical signs displayed by the horse (7).

In several studies thermography has been successfully used to visualize neck or back dysfunctions. In a study with 51 horses showing signs of reduced or abnormal movement in the spine, a diagnosis of somatic dysfunction was made, confirmed by thermographic imaging. In 45% of horses, no specific primary cause could be identified using radiography and/or scintigraphy imaging modalities. Spinal dysfunction relates poorly with pathological lesions, equal to what is also shown in human medicine. It is recognized that osseous changes correlate poorly with compromised function or any pain displayed by the horse.

Neck and back problems can be a secondary complicating factor in the diagnostic process investigating chronic lameness. Neuromuscular in origin, the presence of a somatic dysfunction is frequently overlooked. Therefore a clinically made diagnosis , often presenting as clinical symptoms of abnormal posture, gait or behavioral issues, can be confirmed using thermography (9).

A study comparing the correlation between different diagnostic modalities found a good correlation in cases with echography (66.7%), scintigraphy (75%) but only in 51.7% of radiography cases. This might be due to the less effective detection of chronic bone injuries. The sensitivity to detection of supraspinous and interspinous desmopathy did not correlate well with the echographic findings. Impinging spinous processes, kissing spines, did not elect any thermographic changes in this study (13). Another study on 24 quarter horses, found that the displayed thermographic hot spots all corresponded to lesions seen on echography. Again, for kissing spines, no thermographic reactions where seen, confirming previous other studies that this is often a subclinical condition with no causality in the displayed symptoms.

In contrast, in the lumbar region, a full relation was seen in all horses. Predominantly cold spots where seen here and these occurred in cases of dorsal intervertebral osteoarthritis. As local pain is mostly seen here, in the absence of inflammation, this leads to vasoconstriction , presenting itself as a ‘cold’ thermal pattern. Cold spots over the vertebral column , however, are not associated with chronic lesions. Affected autonomic nerve supply may decrease temperature due to swelling, indicating a more recent injury. A specific pattern, root signatures, is seen when irritation of the local sympathetic nerves are in place. Sacroiliac (SI) ligamental changes present itself clearly as an cold spot and correlated well with the echographic image showing SI ligamentous changes(7).

The high prevalence of back pain in horses, and other musculoskeletal disfunctions could bring thermography forward as an aid to help locate inflammation. A lack of golden standard in equine back thermal imaging raises some entry barriers today to the usage of this diagnostic to its full potential (17,19). At FEI-events, thermographic imaging of all 4 legs is included for some time in its regulation (limb sensitivity examination),which can lead to withdrawal of the horse from the event in case of significant findings (12).

The diagnostic abilities of this method has of course it's limitations. In joint diseases, no correlation can be made between the degree of thermal changes and the degree of joint damage. Reorganization of tendon fibers is best evaluated trough echography, as the thermal changes seen on imaging do not correlate with the structural reorganization happening in tendon lesions. It's greatest diagnostic potential lies in the detection of muscle strains.

For equine osteopaths, MIT can be a valuable tool to complement the palpatory findings. In a questionnaire, with 204 responding Swedish horse owners, 52% stated to contact a complementary therapist first in case of back pain in their horse compared to 45% , who would contact a veterinarian first. Of these owners, 80% reported having experienced locomotor problems in their horse, which 48% of them reappearing (8).

Early detection and prevention of lesions by thermography

The MIT technique is directly related to blood flow. Therefore, it's detection of heat before any palpable physical changes could be useful in the early detection of lesions. As a non-invasive method, it has proven to be useful in early intervention and identification of laminitis, stress fractures and stress injuries to the contralateral limb of orthopedic patients . MIT makes detection of altered blood flow possible in the contralateral foot before laminitis is even present and becomes irreversible (6,7). Studies have also shown the value of MIT in the monitorization of the recovery of distal limb sores, to help guide cast changes and avoid complications associated with prolonged would healing (13).

In lameness detection, is has been shown that thermography can detect subclinical inflammation associated with lameness 2 weeks before clinical symptoms arise. In dorsal metacarpal disease, often seen in race horses (bucked shin), the thermographic changes typically precede the radiographic findings by 2 weeks. Foot lesions characterized by an alteration in blood flow, like palmar foot pain syndrome and thermal stress linked with hoof imbalances can be measured (6,7). Analyses of clinical data of 60 horses revealed a

significant association between chronic laminitis and thoracolumbar spinal injuries. Laminitis horses showcase a 14-fold higher prevalence of thoracolumbar injuries. Although this was only examined using echography, there is potential for MIT to detect co-existing lesions in an early stage (4).

It a study using sixteen 2-year old thoroughbred horses (TB) , a 2- weekly thermographic monitoring was performed to research musculoskeletal changes that occur during training of racehorses. The most common injury in TB is dorsal metacarpal soreness , accounting for 24.1% of all musculoskeletal injuries in these horses. This stress related lesion develops with overtraining and is due to a failure of the bones and joints capacity to adapt to the training demands. These pathophysiological changes are very subtle and require additional diagnostic imaging (CT, MRI,SCI) as these changes are not immediately visible on radiographical images. Radiographic changes in bone take 10-14 days to become visible. The permanent character of any bony changes seen gives little guidance as if a change seen is the cause of the pain and lameness (7). Therefore, an easy and reliable method like MIT for early detection could lead to adaptation of the training schedule to decrease training failure being as high as 26% within less than nine months of training.

In addition, other regions showing thermographic differences where the fore-and hind fetlock and the paravertebral region. The vertebral column is also an important area of lesions and plays a critical role in body balance. After training intensification (gallop), the thoracolumbar area showed a significant thermographic difference compared to the start of the training. Again, often underdiagnosed, of 20% lameness in racehorses in England, 4.35% are linked with low-back pain (14).

Thermographic imaging showed a significant difference between the right - and left sides of the horses bodies during the progression of the training, these were however not linear as training progressed. This study demonstrated the modifications in perfusion in an early stage due to bone remodeling as an adaptation to training.

Trough the early detection of signs of inflammation, thermography can protect the horse. This can allow professionals to adapt the training load accordingly and prevent further injury. For osteopaths, it can help guide treatments and rehabilitation processes by early recognition of for example muscle strains, inflammation, myopathy or tendinopathies, often only later clinically diagnosed by anatomical imaging methodologies. Also in healing processes, the

degree in inflammatory regression can be monitored, as well as the efficacy of NSAID's or other ani-inflammatory medication (13).

Osteopathic treatment monitoring by thermography

A meta-analysis of 8 studies in 525 patients with back pain, clearly shows the statistically significant reduction in back pain after OMT treatment, which is greater than the effect expected from placebo. Pain reductions where twice as high as in non-treated control, and the effect of OMT lasted for at least three months. These clearly demonstrated treatment effects could be potentially be visualized by thermography (2).

A case study in human medicine have been performed using MIT to scientifically support the osteopathic treatment effectiveness and initial diagnosis for back pain. One week after osteopathic manipulative treatment (OMT), images confirmed complete normalization of the initial asymmetry of paravertebral and posterior serratus muscles in a case study on a patient with acute back pain syndrome. Immediate thermography after treatment can be biased by the influence of a physical manipulation on the body (3).

In veterinary medicine, horse owners who were interviewed on the perceived reasons why they would appeal to an complementary therapist, were in strong agreement that the applied therapy worked in their horse. Partial agreement however was obtained on the scientific evidence behind . Thermography can play a role here in visualization and objectivation of an osteopathic treatment (8).

In a long term follow up study, horses showing chronic lameness that was not responsive to allopathic medicine where treated osteopathically under sedation. This study highlighted the presence of somatic dysfunction as a diagnostic entity found in these 51 horses. Patients displayed altered muscle tone, abnormal neck of back function, tenderness and subtle gait changes, without the presence of a clear pathological cause. It was defined as being the primary cause or a complication. The response to treatment was monitored with thermography every 2-6 weeks and then after the horse had resumed work, every 6-8 weeks and at least 6 months after. All cased showed initial significant abnormalities on MIT, showcasing a temperature decrease (at least 1.5°C colder). Other frequently seen abnormalities included loss of symmetrical thermographic pattern and hot dorsal midline. During the period of treatment, 90.2% resumed normal work, out of which 53.1% of cases compared to previous work could maintain heavy work for at least 12 months at a better level of work, 31.2% returned to work at a lower level, and 15.6% showed an unsatisfactory long-term response.

However, from all these horses that returned to work (short-term- after treatment), thermographic abnormalities improved or disappeared, re-establishing a normal image in these horses (9).

A case study on segmental joint dysfunction in a 9-year old quarter horse, objectified with thermographic imaging the improved performance seen after joint manipulation. As thermography measures the indirect status of the autonomic nervous system, joint manipulation is known to improve autonomic nerve dysfunction. Persistent sympathetic involvement in chronic pain creates vasoconstriction, resulting in focal hypothermic images. Result after manipulation showed vasogenic changes in the SI joints, and carpus. Overall asymmetry dropped 79% in total and hypothermic area's increased with a statistically significant 5°C in temperature. These findings confirm the nociceptive alterations in the affected joints, caused by changes in the autonomic nerve system due to joint manipulation. To power up this study, confounding variables that could influence whole body temperature where also taken into account. A difference of 0.2°C was found in 15 different areas, thus excluding any other factors that could influence pre-and post-treatment temperature variations, like muscle activity or environmental temperature (11).

MIT can successfully be used as a tool to monitor treatment progress. Not only as a guidance for the osteopath, it can also be used in scientific research to objectively measure the results of an osteopathic treatment and visualize its effects on the autonomic nervous system.

Conclusion

The palpatory and orthopedic examination still remains the foundation of the diagnostic process performed by osteopaths. However, objective measurements like thermography can meet modern expectations in high-performing sport horses to visualize treatment, detect early changes and allow adjustment of the training. It's sensitivity to artefacts, lack of training accessibilities for professionals and the lack of standardized protocols make it a challenge using MIT in practice. Thorough experience is warranted to differentiate between normal and abnormal thermic patterns. However, there is a considerable body of scientific evidence showing that thermography can be a valuable complementary tool to aid in the diagnosis, early recognition and treatment of horses.

Further application of this technique could contribute to the scientific objectification of various treatments, which in the veterinary field are still predominantly evaluated based on

subjective treatment-effect observations. Guidelines encompassing the thermal imaging of back pain can help clinicians overcome the entrance barriers to this imaging technique and help its distribution of use amongst osteopathic practitioners.

Interviews performed with one veterinarian and one physical therapist using thermographic equipment revealed that the value to clients is still not well known and the economical aspect of time versus costs potentially could overshadow the usage of this interesting diagnostic modality. Potentially AI generated interpretation could help reduce evaluation time of numerous images taken in one session. At the same time as AI models on Rx images are now further refined more research is also needed in the MIT field to make it a more accessible option in daily practice.

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