Pferdeheilkunde 12 (1996) 4 (Juli August) 632–634

Thermography as an aid in the localization of upper hindlimb lameness

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Summary

Thermographic images were very useful in localizing the area of injury in upper hindlimb lameness of horses. The most frequent problems that were noted were muscle strains or muscle inflammation. Three distinct regions were commonly seen: cranial thigh, caudal thigh, and croup region. In the cranial thigh, distinct hot spots were associated with the quadriceps musculature just proximal to the insertion on the patella. In the caudal thigh the most common area of inflammation was at the musculotendinous junction of the semitendinosus muscle. Another area of abnormal thermal patterns commonly seen in the caudal thigh was just caudal to the third trochanter of the femur directly over the biceps femoris. The croup area injuries involved hot spots over the loin region, over the sacroiliac region, over the body of the gluteal muscle, and over the third trochanter.

Keywords: horse, muscle injury, myopathy, thermography, diagnostic techniques

Thermographie als Hilfe bei der Lokalisation von Lahmheiten im oberen Bereich der Hinterhand

Die thermographische Darstellung war sehr hilfreich bei der Lokalisation des Schadensbereiches bei Lahmheiten in der oberen Hinterhand von Pferden. Die am häufigsten auftretenden Probleme waren Muskelzerrungen oder Muskelentzündung. Drei verschiedene Regionen wurden in der Regel untersucht: der kraniale und kaudale Oberschenkelbereich und die Kruppenregion. Im Bereich des kranialen Oberschenkels waren verschiedene warme Stellen assoziiert mit der Quadriceps-Muskulatur direkt proximal ihres Ansatzes an der Kniescheibe. Im Bereich des kaudalen Oberschenkels traten Entzündungen am häufigsten am Musculus semitendinosus auf, und zwar an der Übergangsstelle in seine Sehne. Ein anderer Bereich mit abnormalem Temperaturmuster, der am kaudalen Oberschenkel häufig zu finden war, lag caudal des Trochanter tertius des Femurs direkt oberhalb des Musculus biceps femoris. Verletzungen im Kruppenbereich führten zu warmen Stellen oberhalb der Lenden- und Kreuzdarmbeinregion, der Glutäenmuskulatur und des Trochanter tertius.

Schlüsselwörter: Pferd, Muskelverletzung, Myopathie, Thermographie, Diagnosetechniken

Introduction

Thermography is the pictorial representation of the surface temperature of an object (*Purohit* and *McCoy* 1980, *Turner* et al. 1986). It is a non-invasive technique that measures emitted heat. A medical thermogram represents the surface temperatures of skin making thermography useful for the detection of inflammation. Although thermographic images measure only skin temperature, they also reflect alterations in circulation of deeper tissues. This ability to non-invasively assess inflammatory change, makes thermography an ideal imaging tool to aid in the diagnosis of certain lameness conditions in the horse.

Muscle injuries are uncommonly documented as a cause of lameness in the horse. Fibrotic myopathy, stringhalt, and ruptured peroneus tertius are among the only muscle injuries reported in the horse (*Turner* 1987). These lamenesses are usually characterized by the resultant gait abnormalities. Other muscle problems such as stress tetany, synchronous diaphragmatic flutter, exhaustion, post exercise fatigue, tying-up (exertional rhabdomyolysis), and azoturia are regarded as specific physiologic disturbances (*Hodgson* 1985, *Jones* 1989). Muscle injuries frequently cause lameness in human athletes and racing greyhounds. Similar injuries therefore would be expected in the horse.

Factors which predispose to muscle strains include cold temperatures or impaired circulation to the muscle, local or generalized muscle fatigue, poor or insufficient training, and insufficient warm-up (*Krejci* and *Koch* 1979). Cold has been shown to increase muscle tension and cause circulatory disturbances. This phenomenon causes earlier muscle fatigue which can lead to uncoordinated muscle movement and strain. Fatigue predisposes to injury in two ways. First, muscle fatigue is a manifestation of general fatigue which affects those groups that are maximally loaded. As muscles fatigue they decrease in performance and elasticity thus enhancing the likelihood of strain. Further general fatigue results in central nervous system incoordination of movement and predisposition to strain. Therefore, training must be designed to progressively increase the work load to develop the muscle groups, and to decrease early fatigue and permit rapid restoration of muscle function after exertion. Insufficient warm-up of muscles prior to exercise results in decreased circulation and lowered capacity to eliminate muscle waste products. Both these factors decrease the muscle's ability to sustain maximal performance.

The equine athlete is exposed to these predisposing factors on a routine basis. Hypothetically, if the horse suffers muscle strains, these injuries would most likely be manifested as lameness. The difficulty for the veterinarian is the positive diagnosis of these injuries. In human medicine, the athlete's description of the pain location is often the single most important factor in diagnosis (*Krejci* and *Koch* 1979). This diagnostic aid is obviously lacking in veterinary medicine. Many of these cases probably go undiagnosed in equine medicine because they cannot be confirmed by commonly used diagnostic methods such as radiographs and nerve blocks. As such, these lamenesses are most likely treated empirically with various combinations of rest, analgesics, and anti-inflammatory agents. The purpose of this paper is to describe the thermographic patterns associated with upper hindlimb lameness that could not be explained by joint or skeletal problems.

Materials and methods

Records from 565 cases of upper limb lameness presented from 1986 through 1995 to the University of Florida, Rochester Equine Clinic, and the University of Minnesota were used to characterize the various thermographic patterns associated with upper hindlimb lameness not associated with joint or skeletal problems of the horse. The chief client complaint in each case was either lameness or gait abnormality. In each case, notations were made as to the horse's age, breed, sex, and use. The degree of lameness and limb(s) involved in each case were recorded. Lameness was evaluated on the AAEP grading system. Further information that was collected was the characterization of the horse's gait, response to flexion tests, areas of pain detected by palpation, thermographic abnormalities, diagnosis, and treatment. For the purposes of this manuscript only the thermographic results are presented with a summary of clinical signs. Three different types of thermographic cameras were used to collect the information: an Agema 870, an Inframetrics 520, and a Flir IQ325.

Thermographic lesions were defined as those with a one degree centigrade disparity in temperature. These disparities could consist of an increase or a decrease in temperature. Increases in temperature were suggestive of vasodilation associated with inflammation, whereas decreases in temperature were indicative of either chronic scarring and reduced circulation or local edema, swelling, and vascular stasis due to severe inflammation.

On the basis of the thermographic and clinical findings, the horse's injury could be further categorized as one of three types of muscle injury: cranial thigh, caudal thigh, and croup region. The cranial thigh muscle injuries included injuries where the thermographic abnormality was over the quadriceps musculature, the caudal thigh myopathy which included those cases in which the primary thermographic abnormalities were located over the caudal thigh from the sacrum to the gaskin, and the croup myopathy which included cases shown thermographically to have inflammation involving the caudal loin, sacroiliac region, and hip.

Results

In the upper hindlimb of the horse significant thermal changes were identified as either hot spots or cold spots, reflecting the presence or absence of swelling in the damaged tissue. The thermographic image was very useful in localizing the area of injury but did not characterize the specific nature or etiology of the injury. The most frequent hindlimb problems noted thermographically were noted over muscles. It is author's opinion that this may represent either muscle strains or muscle inflammation. In the cranial thigh, distinct hot spots were associated with the quadriceps musculature just proximal to the insertion on the patella. Many of the cases were presented for possible patella problems because of the prominence and slight lateral deviation of the patella. In each case, ultrasonography of the region of the "hot spot" revealed disruption of normal muscle fibers and varying sizes of hypoechogenicity typical of hemorrhage.

The caudal thigh thermography showed several common areas of abnormal heat: The most common was at the musculotendinous junction of the semitendinosus muscle. These horses typically presented with the hoof slap gait typical of fibrotic myopathy. Sonography of these cases revealed 2 different types of change, a hyperechogenicity thought to be early fibrosis and a disruption of normal muscle/tendon patterns with focal hypoechogenic areas suggesting tearing of the musculotendinous junction. A third area of abnormal thermal patterns was commonly seen in the caudal thigh, just caudal to the third trochanter of the femur directly over the biceps femoris. These horses typically presented with grade III/V lame or worse and there was intense pain associated with pressure over this region. The thermal changes noted were both a hot spot and an intense cold spot. We have not correlated any sonographic findings with this injury to date. However, this is the same region that has been noted on soft tissue scintigraphy and thought to be a site of focal muscle injury (*Morris* et al. 1991)

The croup area injuries involved hot spots over the loin region, over the sacroiliac region, over the body of the gluteal muscle, and over the third trochanter. These horses usually presented with more subtle and more variable lameness. The owners/riders complained frequently that the horse was sore in their backs or stifles. The horses typically traveled short behind, had poor acceptance of the bit, and tended to move in a "hollow" manner. Many of the horses were not lame at the time of examination but did have a history of lameness or gait problems. The remainder of the horses were grade 1 to 3 of 5 lame. Horses affected by croup muscle pain were less lame than horses with caudal thigh myopathy. No consistent sonographic findings were found in these cases, however evidence of fasciitis was seen on muscle biopsy of one case.

Specific notations were made in the records as to gait abnormality. These notations included stiffness (loss of flexion), toe dragging, shortness of stride, hoof slap, and 'hip hike' or hitch. Horses with croup muscle pain were more likely to exhibit stiffness, toe dragging or short striding. The horses in the caudal thigh muscle injury group were more likely to show a "hip hike" or hoof slap. The cranial thigh muscle injuries usually presented with an acute lameness of grade 3 of 5. The lameness usually improved within one week but each case was characterized by a prominent patella and outward rotation of the stifle.

Flexion of the hindlimbs rarely exacerbated the lameness in any of these cases. However, most horses did have a palpable area of pain over the muscles of the hindlimb. The area of pain corresponded to the abnormal area(s) noted during thermographic evaluation in about two-thirds of the cases. The horses were either not lame or were grade 1 lame were the least likely to show areas of palpable pain; thermography generally indicated the area of pain in 50% of these horses. Horses that were more lame were most likely to exhibit an area of palpable pain which corresponded to the thermographic lesion(s), correlated in over 90% of the cases.

Discussion

Metabolic muscle diseases have been well described in the horse (*Hodgson* 1985, *Jones* 1989). The effects of these diseases on performance are well known. Generally, fatigue or metabolic disturbances have been the underlying cause of the muscle dysfunction (*Jones* 1989). These diseases can be documented by serum electrolyte and tissue enzyme disturbances, electromyography, and muscle biopsy (*Hodgson,* 1985). Muscle strain cannot be as easily diagnosed. Serum levels of muscle enzymes will be elevated only if there has been actual tearing of muscle tissue; the extent of the enzyme elevation would depend on the amount of muscle tissue damage (*Krejci* and *Koch* 1979). The ability of electromyography to diagnose muscle strain has been equivocal in human medicine. These types of muscle injuries in the horse have rarely been described (*Turner* 1989). This is probably due to the difficulty in documenting the injury with objective data. However, there is no reason to believe that these types of injuries do not occur in the horse (*Jeffcott* 1981). Thermography may have its greatest clinical application in the assessment of individual muscle injuries which are difficult to diagnose

(*Turner* 1989). Even though serum muscle enzyme elevation may non-specifically indicate muscle damage, the specific muscle or muscles damaged may be difficult to identify. Thermography offers two types of information important in the evaluation of muscle injury: first it can locate an area of inflammation associated with a muscle or muscle group; and second is that it illustrates atrophy well before it becomes apparent clinically.

Muscle inflammation will be most commonly seen thermographically as a "hot spot" in the skin directly overlying the affected muscle (*Turner* 1989). On a rare occasion, swelling and edema in the affected muscle will be severe enough to inhibit blood flow through the muscle. In this case the injured muscle will be seen thermographically as a "cold spot". Thermographic evaluation of muscle must be made from paired samples, that is comparison of the right and left sides. These comparison images should be nearly identical. Consistent variations from side to side would indicate muscle damage located at either the "hot" or "cold spot".

The most common cause of muscle inflammation is muscle strain (*Krejci* and *Koch* 1979). A classification of first, second or third degree strain injuries, described in human athletes, has been applied to horses (*Turner* 1989). In this study we were able to discern three major areas of injury. One, the croup myopathy, involved inflammation over the areas of the longissimus lumborum m., gluteus medius m., gluteus profundus m., the sacroiliac joint, and the gluteal insertions on the greater trochanter and associated fascia. The analogous regions in man would constitute the lower back and hip. The second, the caudal thigh myopathy, involved the areas over the biceps femoris m., the semitendinosus m., the semimembranosus m., and their origins and their upper limb insertions and musculotendinous attachments. The third, the cranial thigh injury, constitutes damage to the quadriceps and tensor fascia lata.

A gluteal tendon lameness has been described in the horse; the major clinical sign was pain around the greater trochanter (*Pearson* 1986). There have been numerous reports of the effect of lumbar and sacroiliac pain leading to lameness (*Jeffcott* 1975, *Jeffcott* 1981, *Jeffcott* and *Dalin* 1985). For the cases reported here we chose to place all these problems in one of three categories because, although physical examination revealed soft tissue pain and imaging of the areas by thermographic examination confirmed the location of lesion(s), these methods could not specifically identify the structures involved. Thermography only reflects problems of deeper tissues, i.e., it indicates the area of disease but does not reveal any information as to the nature of the organic damage. We grouped these problems together because of their close anatomical location and similar effects on the horse's gait (*Dyce* 1987).

Muscle injuries in the horse have been described as ranging from loss of performance to pain created by a particular movement to overt lameness (*Meagher* 1985). The wide range of degree of lameness in these cases supports this observation. The cases presented in this report indicate that the caudal thigh myopathy was more likely to cause severe lameness than the cranial thigh or croup muscle injuries. The caudal thigh muscles may be more likely to tear, and tears in this group of muscles have been documented (*Turner* and *Trotter* 1984). Fibrotic myopathy, a condition of the horse that involves the semitendinosus muscle and occasionally the semimembranosus and biceps femoris muscles, is thought to originate from trauma to the musculotendinous junction. Another possible reason for the greater pain associated with these injuries is the complex actions of these muscles (*Dyce* 1987). This group of muscles extends the hip, flexes the stifle, and extends the hock. Because of the action of the horse's reciprocal apparatus all three functions cannot occur simultaneously unless muscle contraction is coordinated. Hypothetically, if an injury occurred, the horse should have pain each time the leg was extended because stifle extension would exert a direct opposing force on the caudal thigh muscles as they contract for hip and hock extension.

Pain on palpation was probably the single most important physical evidence of injury. Pain elicited by palpation should be repeatable, but care should be taken not to overdo palpation which may result in the horse "guarding" the injury and thus not responding. We found that firm pressure was more reliable than squeezing muscle masses when trying to differentiate pain from simple annoyance. Stress points have been described that help point to lesions of these muscles (*Meagher* 1985). Stress points are the points where the greatest stress produced by movement occurs.

Thermography was used in these cases as a diagnostic tool. In each case, information from thermography was important in the rendering of a diagnosis. Thermography has been shown to be a practical aid in the clinical evaluation of lameness. This modality specifically increases the accuracy of diagnosis by confirming inflammation in palpably sore areas and by showing the area to concentrate further diagnostic testing such as, sonography, radiography, or muscle biopsy. Clinically, thermography also improves therapy. Once the area of inflammation is determined physical therapy can be applied directly to that area. In this fashion therapeutic ultrasound, massage, or other treatment is applied more specifically to the inflamed area. Further, thermography can be used to monitor the resolution of the inflammatory process.

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