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The effect of ambient temperature on infrared thermographic images of joints in the distal forelimbs of healthy racehorses

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ABSTRACT

The aim of the study was to describe the dependence on ambient temperature of distal joint temperature at the forelimbs of racehorses. The study also investigated the influence of differing ambient temperatures on the temperature difference between joints: this was measured ipsilaterally (i.e. between the carpal and fetlock joints along each forelimb) and contralaterally (i.e. between the same joints of the left and right forelimbs). Sixty-four healthy racehorses were monitored over 10 months. At each session, three thermographic images were taken of the dorsal, lateral and medial aspects of the distal forelimbs. Temperature measurements were made from regions of interest (ROIs) covering the carpal and fetlock joints. There was a strong correlation between ambient temperature and absolute joint temperature at all ROIs. The study also observed a moderate correlation between ambient temperature and the ipsilateral temperature differences between joints when measured from the medial and lateral aspects. No significant correlation was noted when measured dorsally. The mean contralateral temperature differences between joints were all close to 0 °C. The data support previous reports that the temperature distribution between the forelimbs of the healthy equine is generally symmetric, although some horses differ markedly from the average findings.

1. Introduction

To measure equine body surface temperature, methods such as palpation and contact thermometry can be used (Palmer, 1981), but the temperature can also be measured by means of infrared radiation using non –contact infrared thermography (IRT). This provides a pictorial representation of the body surface temperature distribution in animals (Speakman and Ward, 1998; Stewart et al., 2005; Luzi et al., 2013). The temperature measured from the skin surface is related to the local dermal microcirculation, perfusion in subcutaneous structures (joints, muscle), the thermal properties of the skin and hair coat, and the thermal gradient between the skin surface and the environment (Cena and Clark, 1973; Purohit and McCoy, 1980; Palmer, 1983; Turner, 1991). Surface temperature is therefore the combined result of the heat produced by the body and the impact of environmental factors such as air temperature, humidity (Soroko et al., 2014), and wind speed (Westermann et al., 2013; Wojtas et al., 2013).

In the equine, skin temperature as measured by IRT has been correlated with the presence of various inflammatory and autonomic disorders which affect blood flow in the skin or underlying superficial structures (Turner, 2001; Purohit et al., 2006; Luzi et al., 2013). The reliable interpretation of thermographic abnormalities is dependent on a thorough understanding of the normal temperature distribution across the body surface, the likely impact of environmental factors, and strict adherence to imaging protocols to limit any confounding influence from the environment (Head and Dyson, 2001; Purohit, 2009).

Normal thermographic patterns for the horse have been described, with a high degree of symmetry between left and right sides of the body reported (Purohit and McCoy, 1980; Palmer, 1981, 1983). This allows the creation of a map of the normal temperature distribution of the symmetrical parts of the body of a horse at rest. Several studies have attempted to establish normal thermographic patterns under a variety of environmental conditions (Vaden et al., 1980; Palmer, 1983; Turner, 1991; Mogg and Pollitt, 1992; Waldsmith and Oltman, 1994; Soroko et al., 2016).

Thermographic evaluation of the distal parts of the limbs is complicated by their enhanced thermoregulatory role, which is particularly sensitive to environmental temperature. A cool environment leads to peripheral vasoconstriction, increasing blood volume centrally

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and maintaining a stable core temperature (Wallsten et al., 2012). The influence of ambient temperature on the surface temperature of the distal forelimbs has been discussed in several studies. Palmer (1983), using a portable infrared thermometer, showed that distal limb temperature varied with ambient temperature, but with appreciable differences between horses at lower ambient temperatures. Our own group's previous research on racehorses (Soroko et al., 2016) found a strong correlation between limb surface temperature and ambient temperature (which varied over approximately 20 °C during the 10-month study period). Purohit and McCoy (1980) demonstrated some consistent general characteristics of thermal patterns in the limbs, but the horses in their study presented with a wide range of absolute limb surface temperatures.

Modern thermography allows the accurate quantification of skin surface temperature from user-defined regions of interest (ROIs), but a limitation of many of the early studies on limb temperature is their qualitative or semi-quantitative nature. Temperature patterns were typically described, with the thermogram presented, without temperature calculations from anatomically relevant ROIs. Better data are particularly required from the distal joints, which are the most common sites of injury or sub-clinical inflammation in performance horses (Dyson, 2000; Reed et al., 2012). Recent improvements in thermal camera technology (higher spatial resolution, improved temperature accuracy and better image analysis software) now permit good quantitative data to be acquired.

Therefore, the aim of our study was to describe the dependence on ambient temperature of distal joint temperature at the forelimbs of racehorses using a modern, high-performance thermal imager. We employed ROIs covering the dorsal, medial and lateral aspects of the carpal and fetlock joints.

We also investigated the influence of ambient temperature on the temperature difference between joints: this was measured both ipsilaterally (i.e. between the carpal and fetlock joints along each forelimb) and contralaterally (i.e. between the same joints of the left and right forelimbs, as a measure of temperature symmetry across the limbs).

The overall objective was to provide accurate numerical reference data on distal joint temperature in racehorses, using imaging technology representative of that now widely available to veterinarians and researchers.

Referring to the previously-published descriptions, we hypothesized that ambient temperature would be strongly correlated both with absolute joint temperature, and also the ipsilateral temperature gradient between joints (due to vasomotor activity in the more distal parts of the limb). On the basis that peripheral vasoconstriction and vasodilatation would occur symmetrically in the limbs, we did not anticipate significant correlations between the contralateral joint temperature gradients and ambient temperature.

2. Materials and methods

Thermography measurements were obtained from 64 race horses of three breeds (30 Polish Half Breed; 15 Thoroughbred; 19 Arabians) aged 3–5 years. All horses were being trained for flat racing in a clockwise direction at Partynice Race Course (Poland) during the 2011 or 2012 season, and were housed in individual stalls with common management and training regimes. A total of 13 imaging sessions for each horse were conducted over a period of 10 months.

The protocol for thermography was as previously described by Van Hoogmoed et. al. (2000) and Soroko et. al. (2013). Horses were examined at rest before daily exercise, and 40 min after feeding. Dirt and mud present in the imaging field of view was brushed away, and 15 min were allowed to pass before scanning to ensure the transient heat generated by brushing had subsided before obtaining measurements. To minimize the effect of environmental factors, thermography was always performed within an enclosed stable.

At each imaging session a series of three thermographic images were taken of the dorsal, lateral and medial aspects of the distal part of the forelimbs (Figs. 1–3) using a VarioCam hr infrared camera (uncooled microbolometer focal plane array, resolution 640 × 480 pixels, spectral range 7.5–14 µm, InfraTec, Dresden, Germany). The

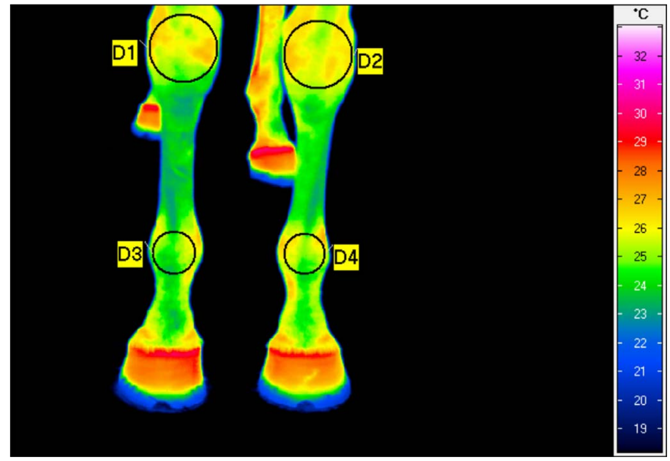

Fig. 1. Thermogram of dorsal aspect of distal part of forelimbs. Measured ROIs: D1 - right carpal joint, dorsal aspect; D2 - left carpal joint, dorsal aspect; D3 - right fetlock joint, dorsal aspect; D4 - left fetlock joint, dorsal aspect.

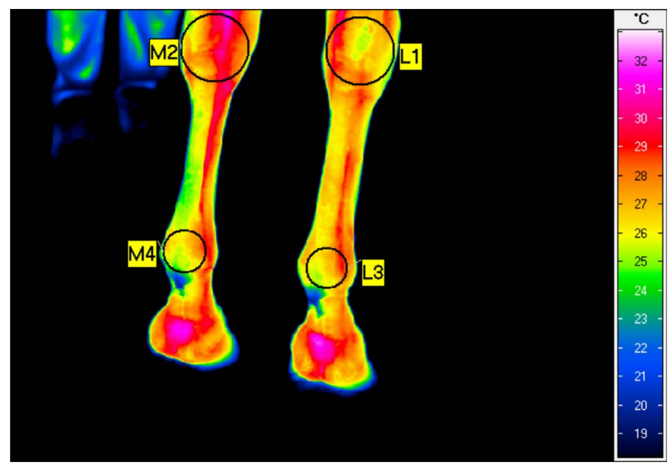

Fig. 2. Thermogram of right lateral and left medial aspects of distal part of the forelimbs. Measured ROIs: L1 - right carpal joint, lateral aspect; M2 - left carpal joint, medial aspect; L3 – right fetlock joint, lateral aspect; M4- left fetlock joint, medial aspect.

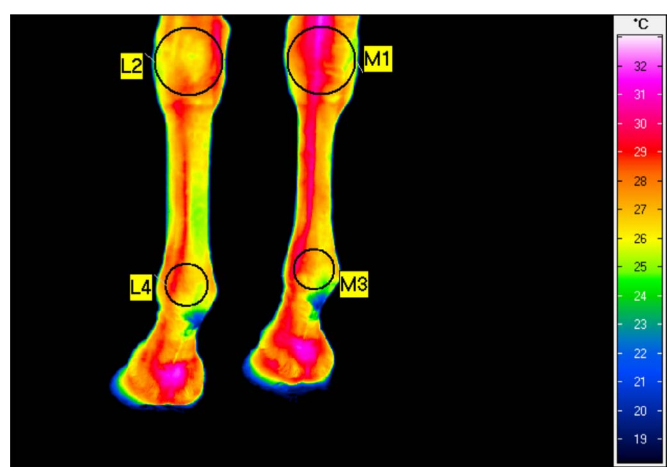

Fig. 3. Thermogram of left lateral and right medial aspects of distal part of the forelimbs. Measured ROIs: M1 - right carpal joint, medial aspect; L2 - left carpal joint, lateral aspect; M3 - right fetlock joint, medial aspect; L4 - left fetlock joint, lateral aspect.