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Hoof and distal limb surface temperature in the normal pony under constant and changing ambient temperatures

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Summary

Forelimb surface temperatures were continuously monitored in four clinically normal ponies exposed to: (i) constant ambient temperature; (ii) a biphasic change in ambient temperature; and (iii) an incremental increase in ambient temperature. Limb surface temperatures were recorded at the hoof, metacarpus and forearm, and rectal temperature was also measured. Under constant ambient temperature, limb surface temperatures remained relatively constant. A pyrexic episode occurred in one pony under constant ambient temperature conditions and was characterised by an onset phase in which rectal temperature gradually increased while limb surface temperatures concurrently decreased; a plateau phase in which rectal temperature was elevated but essentially constant although limb surface temperatures rose dramatically; and a febrilytic phase in which limb surface temperatures remained elevated while rectal temperature gradually decreased. A biphasic change in ambient temperature produced corresponding changes in limb surface temperature, but limb surface temperatures were less stable at the lower ambient temperatures. Surface temperature responses to incremental increases in ambient temperature were dependent on the baseline ambient temperature (before increase), and dramatic, spontaneous increases in limb surface temperatures were observed. Rectal temperatures in the normal animals remained relatively constant under all three ambient temperature regimens.

It was concluded that clinical interpretation of limb surface temperatures in ponies required an awareness of ambient temperature conditions. For evaluation of vasodilator agents, constant ambient temperatures of at least less than 18°C are suggested, and constant ambient temperatures exceeding 20°C are recommended for the evaluation of vasoconstrictor agents.

Introduction

THE surface temperature of the equine distal limb may be assessed by manual palpation, thermography and electronic thermometry. Manual palpation of distal limb surface temperature has been used to assess tissue perfusion in the developmental and acute phases of equine laminitis (Garner *et al* 1975, Robinson, Scott, Dabney and Jones 1976), but it is a subjective method which merely measures the presence of a temperature gradient between the distal limb surface and the human hand (Palmer 1981). Thermography is the pictorial representation of temperature distribution over an area of skin (Webbon 1978), and has been used in the detection of acute and chronic inflammation (Purohit and McCoy 1980), vascular and neoplastic diseases (Purohit 1980) and in assessment of healing (Stromberg 1974). An electronic thermometer has been used by Webbon (1978) to study surface temperature on the palmar aspect of the equine limb, between the carpus and fetlock.

Surface temperatures in the equine distal limb have been monitored in association with the carbohydrate (CHO) overload model of laminitis and various patterns were reported. Increases in hoof or distal limb surface temperatures were observed either up to 24 h before lameness onset (Purohit and McCoy 1980; Purohit, Hammond, Slone and Ganjam 1982) or associated with the onset of Obel grade 3 lameness (Garner *et al* 1975). The variation in limb surface temperatures during the developmental phase of laminitis suggests that factors other than those associated with the pathogenesis of laminitis may be involved. Indeed, ambient temperature may have affected the limb surface temperatures recorded in horses during the developmental and acute phases of laminitis (Seamans, Asquith and Hoffman 1982).

Palmer (1983) used a portable infrared thermometer to measure surface temperature in the equine distal limb and found that the temperatures varied in proportion to ambient temperature, with considerable variation noted between horses, especially at lower temperatures. This was consistent with observations of Kameya and Yamaoka (1968) who concluded that the major detectable influence on limb surface temperature was ambient temperature, and that distal limb skin temperature was not significantly influenced by weather, atmospheric pressure or humidity. Equine limb surface temperatures were usually symmetrical with a temperature difference of less than 1°C (Webbon 1978). However, when the temperature difference between limbs exceeded this value (9.3% of readings) the ambient temperature was between 16.0 and 21.6°C (mean 18.78°C, standard deviation [sd] 2.54°C) and the mean of the remaining ambient temperature readings was 20.96°C (sd 3.45°C). Further investigation of this phenomenon was suggested by the author.

Previous investigations of normal surface temperature changes in the equine distal limb have used single or multiple isolated measurements, following a stabilisation period. Continuous measurement of distal limb surface temperature has not been undertaken previously. This study reports continuously monitored distal forelimb surface temperatures in ponies under conditions of constant and changing ambient temperatures, and of particular interest was the ambient temperature range of 15–20°C. The aim was to generate guidelines for the clinical and experimental interpretation of limb surface temperature.

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Materials and methods

The ponies

Four clinically normal ponies, bodyweight 111–154 kg, aged 3–5 years, were used. Three were geldings and one was a mare. The ponies were trained to stand in a crush for up to 30 h continuously. Urine and faeces were manually removed from the crush floor. During the temperature trials luceme hay and water were provided *ad libitum*, and between experimental sessions the ponies were grazed on pasture, supplemented with hay. Ivermectin was administered regularly for the control of internal parasites.

Temperature recording apparatus

Temperature sensors (NPN small signal transistors type BC 200) were embedded in epoxy resin. These were used in oscillator circuits in which frequency was proportional to temperature. A circuit board containing the oscillator was located in a plastic housing inserted into the cable leading from the sensor to the datalogger. The datalogger was based on a Commonwealth Scientific and Industrial Research Organization (CSIRO) microprocessor, using a CMOS 6805 CPU with eight channels. Each channel stored 5-min frequency averages and the datalogger stored up to 17 h of data per session. Downloading of data and re-setting the datalogger could be performed with negligible interruption to data continuity, making recording sessions exceeding 17 h possible. The recording equipment was calibrated using water baths for the temperature range 0–50°C.

An RS 232 interface was used to download data from the logger to a portable computer (NEC PC-8201A) and from the portable computer to an IBM-compatible PC in which temperature values were calculated from the frequency data and stored on floppy disks for plotting and analysis.

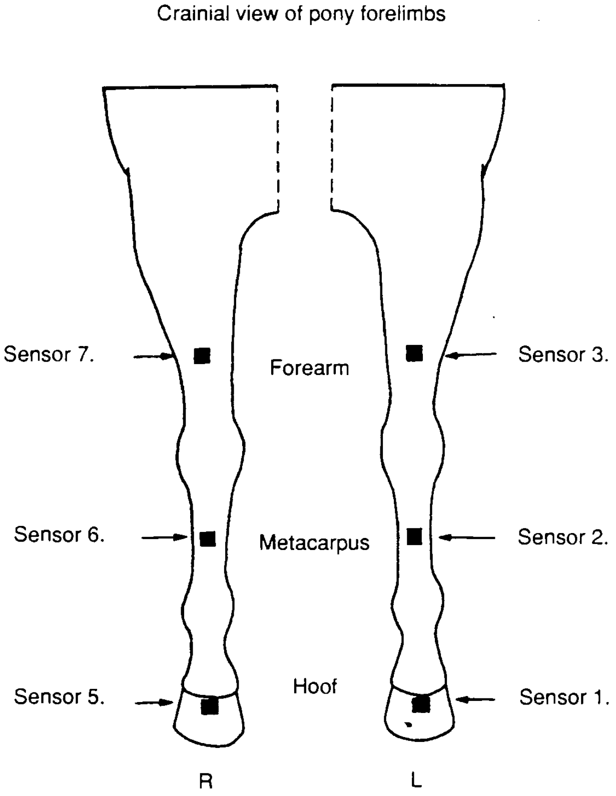

Fig 1: Diagram indicating the sensor placement sites on each forelimb

Sensor sites and attachment

The sensor attachment sites on the forelimb are shown in Figure 1. Sensors 1 and 5 were placed on the dorsal surfaces of the left and right hooves respectively, approximately 1 cm distal to the coronary band. Sensors 2 and 6 were placed over the dorsal mid metacarpus of the left and right limbs respectively. Sensors 3 and 7 were placed dorsally at the level of the junction of the middle and distal thirds of the left and right radius respectively. Sensor 4 was placed 10–15 cm inside the rectum of the geldings and 3–5 cm inside the vagina of the mare. Sensor 8 was suspended adjacent to the crush to record ambient temperature.

The limb sensors were attached to the skin or hoof with a quick-drying multipurpose adhesive ('Multigrip', Selleys). This was covered in 1–2 layers of self-adhesive bandage ('Handygrip', BDF Australia) and 1–2 layers of adhesive bandage ('Elastoplast', Smith and Nephew Pty Ltd, Australia). The adhesive improved contact between the sensor and the skin surface in the presence of hair cover. The dressings insulated the sensor from the environment, thus reducing the effects of sweating and ambient temperature on the sensor. The sensors were removed at the end of each experiment by moistening the contact site with acetone to soften the adhesive.

In the geldings, the rectal sensor was expelled with each defaecation and required repositioning (this was not a problem in the mare in which Sensor 4 was vaginally positioned). Limb sensors occasionally became dislodged during long sessions. When this occurred, the sensors were reattached as described previously.

Ambient temperature conditions

The room in which the studies were conducted had a thermostat and temperature control facilities. The room could be maintained at constant temperature in the range: outside temperature minus 5°C, to approximately 30°C. Outside temperatures were lower in winter, permitting lower room temperatures to be achieved. Room lighting was consistent with the outside photoperiod under the first two ambient temperature regimens.

In the first series of experiments (Constant ambient temperature), ambient temperature was held constant at two-thirds of the maximum thermostat setting for 30 h. In the second series (Biphasic ambient temperature change), ambient temperature was maintained at the minimum thermostat setting for 6 h, increased to the maximum setting for 15 h and returned to the minimum setting for 9 h. Total experiment duration was 30 h. Maximum room temperatures coincided with daylight and minimum temperatures with darkness. These two experimental series were performed in midwinter.

The third series of experiments (Incremental ambient temperature change) involved maintaining ambient temperature at the minimum setting for approximately 3 h followed by equal incremental increases in thermostat setting at 20 min intervals until maximum was achieved (9 increments). Maximum setting was maintained for 20 min followed by a rapid return to the minimum setting. Although this series of experiments was conducted in spring, the experiments were performed during the night to allow lower ambient temperatures to be achieved.

Statistical analysis

Temperature data from limb sites were compared to rectal temperature, ambient temperature and over time using simple correlations (r = correlation coefficient). Temperature differences between the left and right limbs (L-R differences) were compared using student's paired t tests.

Results

Data generated while the rectal sensor was expelled, or during dislodgement of a limb sensor, were not included in the analyses. 'Absent' indicates that data are unavailable due to sensor malfunction. Weighted means and mean L-R differences are given in Tables 1 and 2 respectively.

Constant ambient temperature

The data from Pony 2 are graphed in Figure 2. When ambient temperature was held constant in the range 20–22°C, both rectal and forelimb surface temperatures also remained essentially constant. The limb surface temperatures were more variable than rectal temperature, but low correlation coefficients indicated that little of the variation in limb surface temperature was attributable to changes in rectal temperature. Limb surface temperatures decreased distally with the greatest temperature difference observed between the metacarpus and the hoof. Low correlation coefficients also indicated that variations in rectal and limb surface temperatures were not attributable to changes in ambient temperature. No intrinsic diurnal temperature patterns were observed in rectal or limb surface temperatures.

Surface sites on the right forelimbs of Ponies 3 and 4 were significantly warmer than the corresponding left forelimb sites, and the reverse was true for Pony 1 ($P<0.01$). The right hoof of Pony 2 was significantly warmer than the left, but at the remaining limb sites the left limb was warmer than the right ($P<0.01$). The largest mean temperature difference recorded was 1.5°C, which occurred between the hooves of Pony 3.

Pyrexia: A pyrexic episode was observed in Pony 4 during the last 7 h of the 'Constant ambient temperature' experiment. Data from this segment were excluded from analysis of the constant

TABLE 1: Weighted limb surface temperature means (sd, df = 3) under constant ambient temperature and during the biphasic ambient temperature change experiment

Site	Constant ambient temperature (°C)	Biphasic ambient temperature change (°C) Low ambient	High ambient
Ambient	20.70 (0.09)	16.77 (1.05)	29.10 (0.16)
Left hoof	29.71 (0.84)	27.32 (1.90)	32.57 (0.92)
Right hoof	30.40 (0.45)	27.25 (2.11)	32.48 (0.97)
Left metacarpus	31.79 (1.51)	29.75 (1.80)	33.56 (0.94)
Right metarcarpus	31.78 (0.74)	29.86 (2.27)	33.51 (1.08)
Left forearm	32.80 (0.89)	29.38 (1.70)	33.34 (1.01)
Right forearm	32.69 (1.16)	29.36 (1.43)	33.84 (0.71)
Rectal	37.72 (0.11)	37.47 (0.29)	37.63 (0.24)

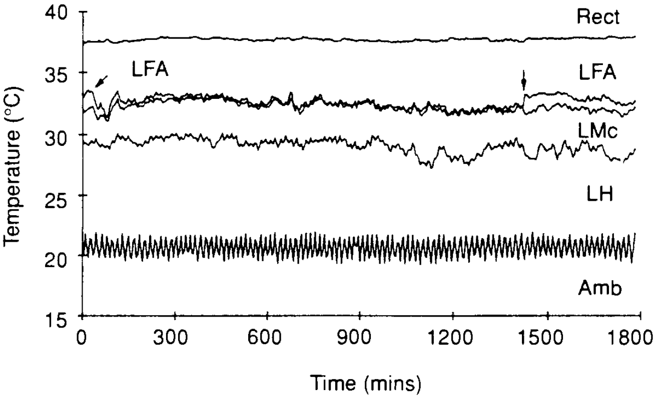

Fig 2: Limb surface temperatures in Pony 2 under constant ambient temperature conditions: Rect: rectal; Amb: ambient; Left; R: right; FA: forearm; Mc: metacarpus; H: hooves

TABLE 2: Mean (sem, df = 90–360) L-R temperature differences (°C) during constant, biphasic changes in, and incremental changes in ambient temperature. During the incremental ambient temperature changes, the values recorded between the first and last re-setting of the thermostat have been included

Site	Pony 1	Pony 2	Pony 3	Pony 4
Hoof	0.58 (0.02)**	-0.89 (0.03)**	-1.51 (0.07)**	-1.02 (0.02)**
Metacarpus	0.75 (0.01)**	0.78 (0.01)**	-1.17 (0.09 **	-0.41 (0.02)**
Forearm	0.28 (0.04)**	0.88 (0.07)**	-0.45 (0.02)**	-0.80 (0.02)**
Biphasic ambient temperature change – high ambient (before temperature change)				
Hoof	-0.08 (0.02)**	0.20 (0.05)**	-0.02 (0.02)	-0.19 (0.02)**
Metacarpus	0.02 (0.01)**	0.41 (0.03)**	0.17 (0.03)**	Absent
Forearm	0.29 (0.06)**	0.16 (0.08)*	-0.04 (0.02)	-0.22 (0.03)**
Biphasic ambient temperature change – low ambient				
Hoof	-0.02 (0.05)	0.66 (0.13)**	-0.01 (0.04)	-0.264 (0.04)**
Metacarpus	0.13 (0.06)*	0.53 (0.03)**	0.41 (0.02)**	Absent
Forearm	0.64 (0.02)**	-2.24 (0.02)**	-1.09 (0.05)**	2.72 (0.19)**
Biphasic ambient temperature change – high ambient (after temperature change)				
Hoof	-0.19 (0.05)**	-0.23 (0.04)**	-0.23 (0.04)**	0.09 (0.03)**
Metacarpus	-0.44 (0.01)**	0.30 (0.03)**	0.48 (0.02)**	Absent
Forearm	0.50 (0.01)**	-0.61 (0.02)**	-0.14 (0.02)**	-2.08 (0.08)**
Incremental ambient temperature change				
Hoof	1.45 (0.13)**	0.55 (0.11)**	-2.97 (0.34)**	1.52 (0.06)**
Metacarpus	0.86 (0.13)**	1.08 (0.02)**	-0.19 (0.21)	1.15 (0.03)**
Forearm	2.05 (0.08)**	1.20 (0.05)**	1.90 (0.05)**	0.19 (0.04)**

*$P < 0.05$; **$P < 0.01$

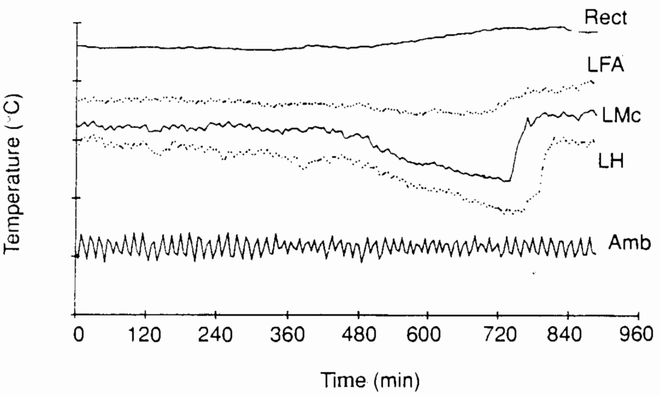

Fig 3: Limb surface temperature in Pony 4 during a pyrexic episode, under constant ambient temperature conditions. Abbreviations as in Figure 2

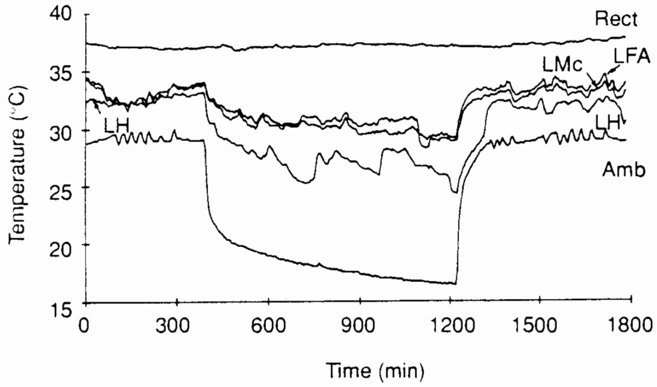

Fig 4: Limb surface temperatures in Pony 1 during the biphasic changes in ambient temperature. Abbreviations as in Figure 2

temperature data because they did not represent a 'normal' animal during this period. The results are presented in Figure 3. Coughing and a serous nasal discharge were observed during the pyrexic period, suggesting that respiratory tract inflammation was present. A follow-up clinical examination of the affected pony, 15 h after the experiment concluded, revealed no abnormalities.

Although only the initial portion of the pyrexic episode was recorded before the end of the experimental period, three phases were discernable (based on changes in rectal temperature): (i) onset phase, (ii) plateau and (iii) resolution phase. During the onset phase, rectal temperature increased and limb surface temperatures steadily decreased, with the greatest temperature decreases being observed at the distal limb sites. The plateau phase occurred when rectal temperature was elevated but stable. Surface site temperatures exhibited dramatic, rapid increases. These increases in temperature resembled those which occurred in Ponies 1 and 3 during the 'Incremental ambient temperature change' experiment (see below). The magnitude of these temperature increases exceeded the decreases of the onset phase resulting in surface temperatures higher than the pre-pyrexia baseline. During the resolution (febrilytic) phase, rectal temperature decreased and the surface site temperatures remained stable above their original baseline. Unfortunately, only the initial portion of this phase was recorded.

Biphasic ambient temperature change

The data from Pony 1 are presented in Figure 4. As in the previous experiments, rectal temperature remained relatively constant. All surface site temperature changes in all four ponies were significantly correlated with ambient temperature ($P<0.01$) changes and the r values were large (r = 0.71 to 0.99), indicating that limb temperatures tended to follow changes in ambient temperature.

The magnitude of the temperature gradient between the limb sites was lowest at high ambient temperatures, and was accentuated after ambient temperature decreased; the temperature differences between the metacarpal and hoof sites were most affected. Limb surface temperatures were more variable at low ambient temperatures, with irregular spontaneous increases in limb temperatures observed. The magnitude of these spontaneous increases was greatest at the hoof sites. Correlations between limb surface and rectal temperature were inconsistent and the correlation coefficients were low. Similarly, the changes in ambient temperature had negligible effects on rectal temperature.

The direction and magnitude of the surface temperature differences between the forelimbs varied with pony and with ambient temperature. The maximum mean difference observed was 2.7°C between the forearm sites of Pony 2 during the low ambient temperature phase.

Incremental ambient temperature change

The results for Ponies 4, 1 and 3, representing the different response types, are presented in Figures 5, 6 and 7 respectively. During the experimental periods for Ponies 2 and 4 (see Fig 5) ambient temperatures less than 20°C were not achieved because of high exterior temperatures (despite the experiments being conducted at night). Therefore, limb surface temperatures for these animals remained high throughout the experimental period, fluctuating with changes in ambient temperature. As in the previous experiment, the temperature gradient between the limb sites was accentuated at the lower ambient temperatures.

Ambient temperatures less than 20°C were achieved during the experimental periods for Ponies 1 and 3. Pony 1 was exposed to initial ambient temperatures between 16 and 18°C (see Fig 6), and dramatic, rapid increases in surface temperature at metacarpal and hoof sites were observed during the incremental increase in ambient temperature. The magnitude of the temperature increases at these sites exceeded that of ambient temperature, at the corresponding times. Pony 3 was exposed to initial ambient temperatures of 18–20°C (see Fig 7). Both forearm and metacarpus sites and the right hoof exhibited rapid temperature increases before the incremental increases in ambient temperature, with the left hoof response resembling that of the limb sites in Pony 1. The result was a delay of about 2.5 h between temperature increases in the right and left hooves. The magnitude of these rapid temperature increases exceeded that of ambient temperature at that time, and appeared to be partly independent of the incremental increase in ambient temperature. Surface site temperatures in all ponies were significantly correlated with ambient temperature (23/24 sites at $P<0.01$ and the remaining site at $P<0.05$), but the correlation coefficients were reduced when compared with those of the 'Biphasic ambient temperature change' experiments.

Left limb sites in Ponies 1, 2 and 4 were warmer than right limb sites. In Pony 3, the right hoof was warmer than the left, the reverse applied to the forearms and the temperature difference between metacarpal sites was not significant. The largest mean temperature difference recorded was 3.0°C between the hooves of Pony 3. The largest actual temperature differences were recorded in Pony 3 as 7.4 and 6.7°C between hooves and metacarpi respectively.

Discussion

Surface temperature increases may be attributed to a net vasodilatation, ie increased flow of warm arterial blood to the skin, and surface temperature decreases may be attributed to net vasoconstriction. The observations made in this study suggest that dilator mechanisms are rapid and effective once activated.

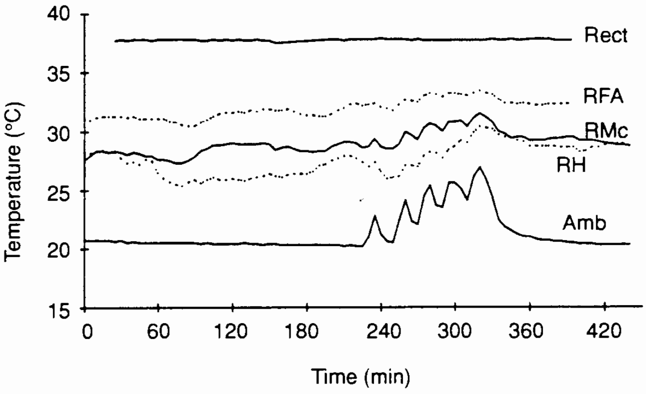

Fig 5: Limb surface temperature in Pony 4 during the incremental changes in ambient temperature (1). Abbreviations as in Figure 2

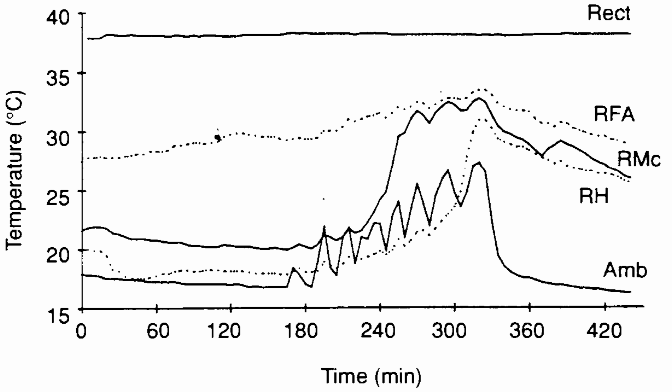

Fig 7: Limb surface temperature in Pony 1 during the incremental changes in ambient temperature (2). Abbreviations as in Figure 2

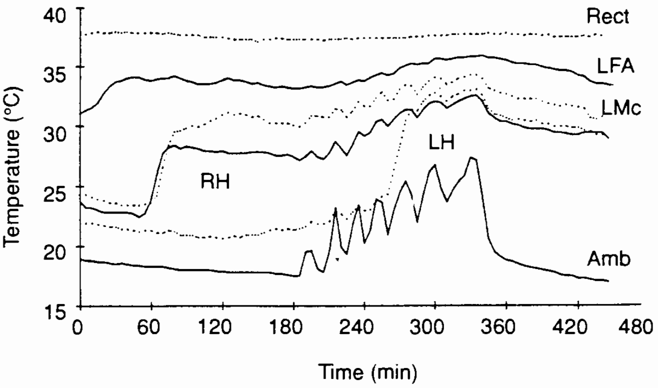

Fig 6: Limb surface temperature in Pony 3 during the incremental changes in ambient temperature (3). Abbreviations as in Figure 2

Studies in sheep, using radioactive microsphere techniques, have demonstrated that arteriovenous anastomoses (AVAs) are thermoregulatory end organs (Hales 1985), and AVAs have been demonstrated in horse skin (Talukdar, Calhoun and Stinson 1972) and in the equine hoof (Schummer 1951; Rooney 1984; Pollitt and Molyneux 1990). AVA density was highest in ear skin and hoof corium (Talukdar *et al* 1972); and in the hoof, AVA density was reported as 500/cm^2 (Pollitt and Molyneux 1990). In other species, AVA density has been found to be high at sites of thermoregulatory importance (Hales 1985). AVA dilatation dramatically increases warm arterial blood flow into subcutaneous venous plexuses, facilitating heat dissipation and consequent increases in surface temperature. AVAs are centrally controlled, but AVA dilatation is inhibited when local surface temperatures exceed core temperature (Hales 1985) as such a temperature gradient would facilitate heat absorption rather than dissipation. In contrast, capillary blood flow is under local control (Hales 1985), increasing in response to warm local temperatures and decreasing in response to cool local temperatures.

The relatively constant limb surface temperatures observed under constant ambient temperature conditions suggest that neither cutaneous vasodilatation nor vasoconstriction was necessary for the ponies to maintain constant core temperatures. A temperature gradient was observed in the forelimb, with surface temperatures decreasing distally, in agreement with the observations of Kameya and Yamaoka (1968), Webbon (1978) Palmer (1981 and 1983). Standard deviations of the mean limb surface temperatures exceeded those observed by Palmer (1981), and the mean rectal temperature was 37.72°C, which lies within the normal range (37.5 – 38.1°C) stated by Palmer (1981).

The results did indicate a slight tendency for surface site temperatures and rectal temperature to decrease over time. This is unlikely to be an energy intake effect as feed and water were provided *ad libitum* during the experimental period. It is possible some deterioration of the adhesive or the covering dressings occurred over the 30 h period. Limited exercise opportunities may also have reduced the heat load of the ponies.

Pyrexia or fever can be described as a state in which the thermoregulatory set-point is raised above normal and body temperature may or may not be raised to the same level (Kluger 1979). The thermoregulatory set-point is the temperature range around which an animal attempts to regulate its body temperature (Kluger 1979). Resetting of the thermoregulatory set-point is mediated by prostaglandin effects on the thermoregulatory centres of the hypothalamus (Milton 1978). The changes in limb surface temperatures observed in Pony 4 resemble those of pyrexia induced in sheep by intravenous administration of *E. coli* lipopolysaccharide (endotoxin) (Blatteis *et al* 1987). This sheep study also demonstrated that peripheral thermoregulatory mechanisms function normally during pyrexia.

The temperature changes observed in Pony 4 can thus be explained as a brief upward resetting of the thermoregulatory set-point. Since actual core temperature was then less than the new set-point, heat conservation mechanisms were activated, peripheral perfusion decreased and surface temperatures consequently decreased. This mechanism effectively increased rectal temperature (onset phase). During the plateau phase the thermoregulatory set-point appears to have once again reset (to normal). Core temperature was now higher than the set-point; heat dissipation mechanisms were activated, peripheral perfusion increased and surface temperatures consequently increased. This mechanism effectively reduced rectal temperature.

During biphasic changes in ambient temperature the limb surface temperatures varied with, and in the same direction as, ambient temperature. This agrees with the findings of Kameya and Yamaoka (1968), Webbon (1978) and Palmer (1983). Diurnal changes in ambient temperature would therefore be expected to produce diurnal changes in limb surface temperatures, with rectal temperature remaining essentially constant (this being the objective of thermoregulation). The magnitude of the limb surface temperature gradient was reduced at higher ambient temperatures, supporting the observations of Kameya and Yamaoka (1968) and Webbon (1978).

Limb surface temperatures appeared unstable at low ambient temperatures, presumably because of periodic cutaneous vasodilatator activity. Such vasodilatator activity may function to dissipate excess bodyheat, warm the peripheral tissues, or both, and may have contributed to the considerable limb surface temperature variation observed between horses at low ambient temperatures by Palmer (1983).

The type of response observed when ambient temperature was incrementally increased varied with baseline ambient temperature. The increase in limb temperatures presumably reflected the incremental increase in ambient temperature over time. However, correlations between ambient temperature and time were smaller and less significant than could be expected from the corresponding changes in limb surface temperatures over time, suggesting involvement of factors other than ambient temperature and time in determination of limb surface temperatures, ie centrally-mediated thermoregulatory responses.

Dramatic, spontaneous vasodilatation occurred when the ambient temperature range of 18–20°C was appraoched from below, and there may be a significant delay (2.5 h or more), before corresponding sites on the opposite limb respond similarly. As no pathology was detected, the asymmetry of vasodilatation appears to be physiological, ie the pony seems able to increase selectively surface temperature at various limb sites. This phenomenon would explain the increase in temperature asymmetry of the equine forelimb in the temperature range 17.0–19.5°C tabulated by Webbon (1978). Palmer (1983) also noted that mean limb temperature asymmetry was greater at an ambient temperature of 15°C than at 5 or 25°C, and although these differences were statistically significant, they were considered to be clinically insignificant; indeed actual L-R differences of up to 5.5°C were recorded and attributed to normal biological variation and subclinical inflammatory processes. However, clinically detectable asymmetry in limb surface temperature appears to be a normal phenomenon under certain ambient temperature conditions and does not necessarily indicate pathology.

Clinically, objective methods of temperature measurement, eg electronic thermometry and infrared thermometry/thermography are preferred over subjective methods (ie manual palpation), and asymmetry of limb sites by greater than 1.5°C can only be considered suggestive of inflammation at the warmer site when:

(i) Ambient temperature is not in the range 18–20°C. Moving the subject to an ambient temperature outside this range, preferably greater than 20°C, should facilitate interpretation of temperature differences. A 1 h stabilisation period after exposure to a different ambient temperature is suggested by Palmer (1983).

(ii) There is other evidence of inflammation, eg pain, as suggested by Palmer (1983).

For thermography of the distal limb, an ambient temperature of less than 25°C was suggested by Stromberg (1974), to maximise the limb temperature gradient. A suitable compromise may be an ambient temperature range of 20–25°C. The clinician should note that pyrexia may produce dramatic changes in surface temperature over a short time, but these changes could be expected to be symmetrical.

For experimental or research purposes a constant ambient temperature regimen would be appropriate for evaluating the effects of drugs on limb surface temperature. For evaluating vasodilating substances, low ambient temperatures are required to ensure that the peripheral vessels are not already dilated. Similarly, higher ambient temperatures are necessary for the evaluation of vasoconstrictor agents. Constant ambient temperatures at least less than 18°C may be a suitable starting point for the study of vasodilator agents, and constant ambient temperatures exceeding 20°C would probably be suitable for the evaluation of vasoconstrictor agents. These recommendations seek to avoid the 18–20°C range in which spontaneous temperature increases have been observed because such spontaneous temperature changes would confound the interpretation of temperature responses. Because large spontaneous cutaneous vasodilatation was only observed in the limbs of two ponies, the lower limit of ambient temperature, above which this phenomenon occurs, may be lower than 18°C. Therefore, further investigation of skin temperature changes, particularly in the ambient temperature range 10–20°C, would be useful to characterise further the pattern of these changes in skin and hoof surface temperatures.

To what extent the temperature changes observed in this study were the result of AVA or capillary dilatation is unkown and warrants further study. The greatest temperature changes were observed in the hoof, where AVA density is high, indicating that changes in AVA flow may significantly influence distal limb surface temperatures. AVAs have also been implicated in the pathogenesis of laminitis, and therefore hoof surface temperatures may yet prove a useful clinical indicator for this disorder.

Acknowledgements

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