

Establishing a yard specific normal rectal temperature reference range for horses.

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Abstract

Previously published equine temperature ranges often fail to state the population of animals or the method of temperature measurement used to establish the range. An inappropriate reference range can negatively affect the interpretation of measurements, resulting in animals being misdiagnosed. A yard specific equine rectal temperature reference range was therefore calculated. 652 rectal temperatures were collected from a population of 41 healthy adult horses, including a range of breeds aged 2-23 years old. Rectal temperature was measured at a depth of 5cm, using lubricated digital predictive thermometers. The normal rectal temperature range of horses on this yard was 36.0 – 38.0°C (90% confidence interval [CI] = 35.97–36.03°C at the lower limit, CI = 37.97–38.03°C at the upper limit). A Mann Whitney test showed significant difference between geldings and mares ($Z = -1.389$, $p = 0.165$). Spearman's correlation showed no significant correlations between rectal temperature and ambient temperature ($R_s = 0.137$, $p = 0.052$), or rectal temperature and horse height ($R_s = -0.047$, $p = 0.791$). The upper limit of the range is lower than most previously suggested temperature ranges, which may reflect the low stress environment in which temperatures were measured; horses were housed in a familiar environment and examined and handled by familiar equine technicians. The findings of this study suggest that establishing yard specific normal temperature ranges could improve early detection of fever, and support biosecurity protocols in the face of infectious disease outbreaks. Additionally, the results suggest that existing equine temperature ranges may need reviewing.

Keywords:

Equine rectal temperature

Normal temperature

Horse temperature

Equine temperature range

Highlights

- Previously published temperature ranges were too high for this population of horses
- The normal rectal temperature range for horses on this yard was 36.0 – 38.0°C
- The range was established using digital thermometers at a rectal depth of 5cm

1. Introduction

Despite increasing emphasis being placed on practising evidence-based veterinary medicine [1], there is very little robust, scientific evidence available for basic clinical examination techniques such as monitoring body temperature. A key component of any thorough clinical examination or biosecurity program remains the measurement and assessment of body temperature. To evaluate body temperature and determine the significance of any changes there must be a clearly defined reference range. Deviation from the normal range can signify disease or debilitation, and routine measurement of body temperature is advised for monitoring equine health and allowing early detection of infections and assessment of disorders such as colic [2]. Yet the normal reference range for equine body temperature when measured with a digital rectal thermometer is poorly defined. Table 1 lists the reference ranges for normal equine rectal temperature stated within the literature and the source of that reference range. As the equine population used to establish these normal ranges and the

method used to measure the horses' temperatures is not stated it is not possible to determine the validity of these ranges when applying them to a defined population of horses, such as those housed on a yard.

Table 1. Previously published normal equine rectal temperature ranges and the methods used to establish them.

Normal rectal temperature reference range (°C)	Source	Method used to establish range
37.0-38.0	Textbook [3]	Primary source not stated
37.2-38.9	Textbook [4]	Primary source not stated
37.5-38.5	Journal article [5]	Primary source not stated
37.2-38.3	Textbook [6]	Primary source not stated
37.5-38.5	Horse welfare society website [7]	Primary source not stated
36.5-38.5	On-line fact sheet for horse owners [8]	Primary source not stated

Recent studies have highlighted the need to review established normal ranges for body temperatures in other species. Konietschke et al. [9] suggest the normal canine temperature range should be 37.2-39.2°C, lower than the previously suggested reference range 37.9 - 39.9°C [10]. Levy et al. [11] measured the resting temperature of 200 healthy cats from rescue shelters, veterinary practices and home environments. This study proposed a normal feline temperature range of 36.7-38.9°C, which is also lower than the previously proposed normal range of 37.7-39.5°C. They suggest that the largely familiar, stress free environment where the cats were examined contributed to marked difference in the upper limit of the interval, as stress can increase body temperature [12].

Within the wider equine literature, studies have reported the rectal temperatures obtained from healthy horses at rest (Table 2). These studies report a variety of different mean temperatures from different populations of horses, but also measure rectal temperature at a

range of rectal depths using different types of thermometer. The variability in rectal temperature probe depth used by these studies could potentially impact the temperature recorded. Green et al. [13] and Verdegaal et al. [14] found equine intestinal temperature measured with an ingestible telemetric device, was consistently higher than rectal temperature at both rest and exercise, by 0.5°C and 0.27°C respectively. This finding is mirrored in canine studies, with a mean difference of 0.4°C between intestinal and rectal temperature reported in exercising Labradors [15]. It is therefore likely that temperatures measured at different rectal depths will vary, so rectal temperature reference ranges should state the rectal depth at which they were established. A horse owner monitoring their animal's body temperature for biosecurity purposes would likely use a standard digital rectal thermometer, rather than a deeper probe such as those used in a research setting. The recommendation for best practice when using a standard digital thermometer is to insert the probe to the level of the display window (see Figure 1), which is around 5cm from the probe tip [16].

Table 2. Mean equine rectal temperatures reported by primary research studies on healthy resting horses. Standard error (SE), standard deviation (SD) and the range are included where they were reported within the study.

Mean resting rectal temperature (°C)	Source	Sample size	Depth of rectal probe (cm)
37.7	Goodwin [17]	18 horses	10
37.6 SE = 0.1	Marlin et al. [18]	5 Thoroughbred horses (2 mares, 3 geldings)	25
38.3 SE= 0.01 Range 37.8 – 38.9	Piccione et al. [19]	10 Thoroughbred mares	15
37.4 SE = 0.06	Green et al. [13]	8 geldings	30
38.4 SE 0.02	Piccione et al. [20]	5 Thoroughbred mares	15
37.3 Range 36.5 – 38.3	Ramey et al. [5]	40 adult horses of mixed breeds and ages	Not reported
37.5 (paddock housed) SD ± 0.2 °C 37.7 (stabled) SD ± 0.2 °C	Schmidt et al. [21]	16 Shetland pony stallions	Not reported
37.6	Verdegaal et al. [14]	7 Standardbred horses	30

Body temperature can be affected by a variety of factors including stress [22,23], exercise [18], disease processes such as endocrine disorders [23], and mounting an immune response to vaccination [24]. It is therefore important to consider the physiological and psychological health of the animals used to establish normal temperature ranges for any species to ensure the animals are truly at rest and not stressed by unfamiliar settings or people. Equine body temperature is also influenced by circadian rhythm [19,25,26], meaning temperatures taken at different times throughout the day must be included in a reference range sampling strategy for it be applicable at all times.

A reference range should be partitioned into subclasses if physiological differences result in variation between the reference limits in each population; potential subclasses include age, sex, and ambient temperature [27]. Sex is known to affect post-exercise body temperature in dogs [28,29], and resting temperature variability in humans [30]. Whilst horses have been shown to tolerate ambient temperatures from -40°C to 40°C with minimal variation in rectal temperature [31], studies monitoring body temperature rarely include long-term monitoring across different seasons. Horses and ponies differ in how quickly they respond to heat exposure and begin sweating [31], suggesting that smaller equids may be able to tolerate a wider body temperature range. It is therefore important to investigate any potential influence of these factors on resting body temperature when determining the scope of a novel equine reference range.

An inappropriate or incorrect reference range can lead to the misinterpretation of results and inappropriate treatment or management of the animal. As body temperature is often used in the diagnosis of infectious diseases, having an accurate and population appropriate reference range is essential to prevent misdiagnosis. An inappropriately high upper reference limit would result in mild pyrexia being missed, therefore subclinical conditions could go unrecognised and could negatively impact biosecurity and welfare.

1.1 *Aims*

The aim of this study was to establish the normal rectal temperature reference range for managed horses living on one equine yard in a temperate climate, using a predictive digital thermometer at a depth of 5cm. Additionally the effects of sex, horse height and ambient temperature on equine body temperature were investigated.

2. Materials and methods

2.1 Ethical statement

This project was approved by Nottingham Trent University's School of Animal, Rural and Environmental Science Ethical Review Group.

2.2 Yard demographic

The yard is located in the East Midlands, United Kingdom, typically housing around 32 horses used for teaching purposes at any time. These horses are long term residents, but participate in regional events on a regular basis. Additionally, students' livery horses are housed in an adjoining yard throughout the academic year. These horses are temporary residents for the duration of the student's studies.

2.3 Animals – reference population recruitment

The reference population was defined to reflect the mixed populations of horses typically encountered on a typical livery yard or riding school (Table 3). The study population recruited consisted of 41 horses from the yard, in regular ridden or in-hand work between 2011 and 2017. The population recruited comprised 16 mares and 25 geldings, aged 2- 23 years (mean age = 13.2 years) of various breeds including Thoroughbreds, Irish Sport horses, Standardbred horses, Cobs, Connemara, and a Suffolk Punch. Horses' heights ranged from 144-183cm measured at the withers.

Table 3. Definition of the reference population.

Characteristic	Reference population criteria
Age	2-23 years old, regularly housed and in some form of training.
Sex	Mares and geldings only
Breed	A range of common breed types including Thoroughbred, Standardbred, Irish Sports Horse and Cob.
Health status	Receiving no medication At least one-month post vaccination Displaying no clinical signs of disease during or in the days following temperature measurement In active work
Management	To have completed any yard quarantine requirements and be housed for at least some of the day as routine husbandry.

All horses recruited to the study were deemed to be fit and healthy by the yard manager, confirmed to be receiving no medications, and showing no obvious clinical signs or recent history to suggest systemic disease. Horses were examined by the researchers for signs of ill health prior to inclusion in the study but were not examined by a veterinary surgeon or subjected to any laboratory tests for infectious diseases.

2.4 Temperature measurement

Horses were examined in a familiar stable or group housed environment. All horses spent at least 30 minutes in the stable to acclimatise before temperature measurements were performed. Replicate rectal temperatures were measured, ranging from 2 - 28 readings per horse (mean = 15 replicates) at different times of the day and during different seasons over a period of up to two years to account for environmental and circadian rhythm effects on body temperature variation [19]. Horses were restrained using a headcollar and lead rope prior to temperature measurement, with familiar technicians handling the horses and performing the temperature measurements. To reflect the standard practice on the yard, measurements were taken by different technicians. All yard technicians are trained to use a standardised method for monitoring temperature, described below.

Rectal temperature was measured using a digital predictive thermometer, either the Digitemp digital thermometer (HealthAid, UK), the V966F Vicks Comfortflex Digital Thermometer (KAZ Incorporated, USA) or a Boots digital thermometer (Boots, UK). All three thermometers were used with KJ Jelly (Johnson and Johnson, UK) lubrication, inserted to the level of the thermometer display window, approximately 5cm into the rectum, held against the rectal wall and removed following the audible alarm to indicate a peak stable temperature had been measured. Thermometers were tested in a water bath at 38°C, compared to a calibrated mercury thermometer and found to be within 0.2°C of the calibrated thermometer as per manufacturer's instructions.

During the final year of data collection ambient temperature was measured using a HI 9564 Thermo Hygrometer (Hanna Instruments Ltd, Bedfordshire, UK) at the time of rectal temperature measurement. Measurements were taken within the stable environment, so there was no effect of wind. Ambient temperature ranged from -0.1-25.5°C throughout the final year of the study period.

2.5 Data analysis

Statistics were calculated using SPSS 24.0 (SPSS Inc., Chicago, IL, USA) with significance set at $p < 0.05$. Replicate temperature readings were performed at different times of the day, or on different days spanning a two-year period therefore each individual rectal temperature reading was treated as a separate data point. A Shapiro-Wilk test of the data showed it to be non-parametric. The effect of horse sex on rectal temperature was investigated using a Mann-Whitney U test. The relationship between rectal temperature and ambient temperature, and rectal temperature and horse height was investigated using Spearman's rank correlation. The reference range was calculated using the method outlined by Friedrichs et al. [27]. A histogram was used to visually identify possible outliers. As the data distribution was not

Gaussian, outliers were analysed with Dixon's outlier range statistic. As the sample size was >120, non-parametric tests with 90% confidence intervals were used to determine the reference interval [27].

To test the reference interval, an additional 20 rectal temperature readings were taken in June 2017 over two days (ambient temperature ranged from 22.2-25.3°C), using 20 horses from the original study population with the same restraint and thermometry methods stated above. The reference interval would be considered valid if no more than two readings fell outside the range [27].

3. Results

652 rectal temperatures were collected from 41 horses. Rectal temperature ranged from 34.5 – 38.3°C (mean =37.1°C, S.D. = 0.51). No significant difference was found between the rectal temperature of mares and geldings ($Z = -1.389$, $p = 0.165$). A weak positive trend was found between ambient temperature and rectal temperature ($R_s = 0.137$, $p = 0.052$). No significant correlation was found between rectal temperature and horse height ($R_s = -0.047$, $p = 0.791$). One outlier was suggested by a histogram of the data (Figure 1), but was retained following analysis [27]. 652 rectal temperatures were therefore used to determine the reference interval for normal equine rectal temperature.

The reference range for normal equine rectal temperature on this yard was found to range from 36.0 – 38.0°C (90% confidence interval [CI] = 35.97–36.03°C at the lower limit, CI = 37.97–38.03°C at the upper limit).

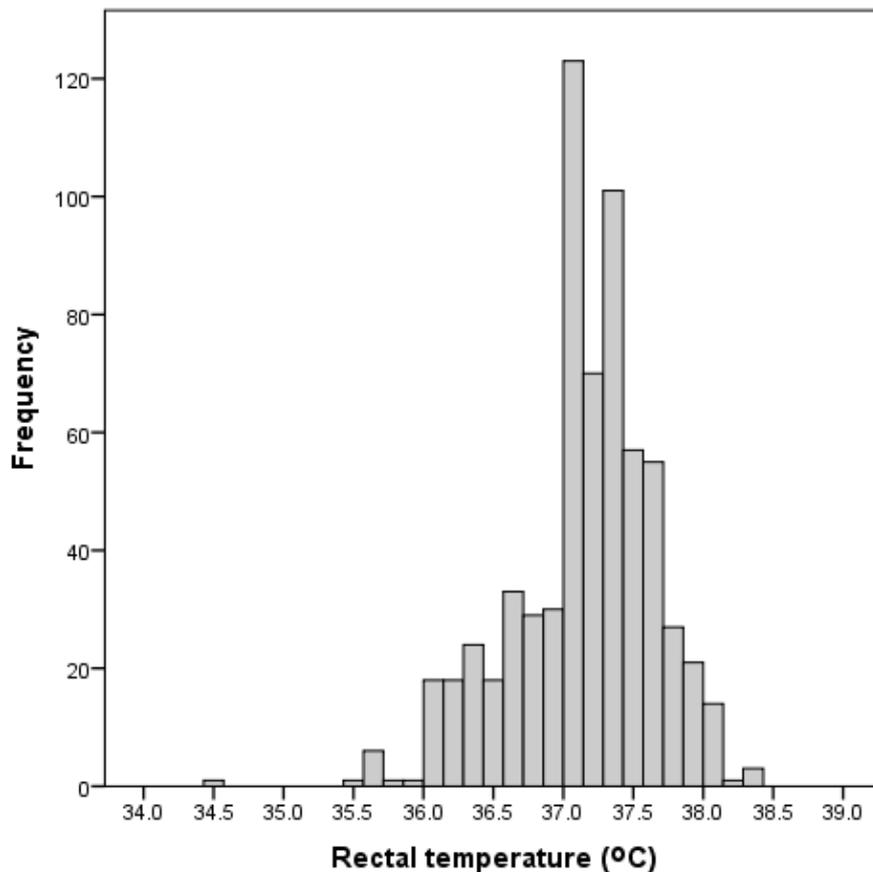


Figure 1. Histogram of temperature frequency for equine rectal temperatures at rest.

An additional 20 rectal temperatures were measured from 20 horses from the same population to test the proposed reference range. These temperatures ranged from 36.9 – 38.0°C (median = 37.65°C). None of these readings fell outside the calculated reference range of 36.0 – 38.0°C therefore the reference range was accepted as accurate for this population of horses [27].

4. Discussion

The normal rectal temperature range for the horses on this yard was found to be 36.0 – 38.0°C, when measured with a digital predictive thermometer at a depth of 5cm. Whilst the upper limit of this yard specific reference range (38.0°C) reflects one previously reported

range [3], the lower limit is around 1°C lower than any of the ranges listed in Table 1. This reference range is however in line with the range currently suggested for donkeys, 36.5 – 37.8° [32] and is similar to the resting temperatures reported from a study of 40 horses in the USA [5]. Only two of the studies presented in Table 2 report a mean resting equine temperature that falls outside this yard's reference range [19,20]. Both studies used rectal thermometers at a depth of 15cm, which could account for the difference. Horse owners are unlikely to be using deep rectal probes to measure their animal's temperature, so a reference range established for a depth of 5cm is more appropriate for their use.

Studies in both cats [11] and dogs [33] have reported no significant correlation between ambient temperature and body temperature. Whilst the correlation between ambient temperature and equine body temperature was not significant in this study, the results did suggest a weak positive trend. This suggests the need for further research on the effect of extreme ambient temperatures (both hot and cold) on resting equine body temperature. Although this study included only mares and geldings, the lack of a significant difference between the two reflects similar findings in dogs [33]. Additionally, the mean rectal temperatures measured from a study investigating Shetland pony stallions housed in both stabled and field conditions, both fall within the reference range established for the equine yard in this study [21].

Individual horses were not subjected to any objective measures of health, such as blood sampling or a thorough clinical examination by a veterinary surgeon. However, as both being examined by a stranger and having blood samples drawn can result in increased activity and stress these procedures could have affected body temperature [22,23]. All horses were monitored throughout the study period, no animals developed any symptoms of clinical disease during this period.

Three different thermometers were used during the study period, potentially introducing additional variation in the results. Whilst ideally the same thermometer would be used for all measurements, the use of different thermometers more closely resembles the real-life situation where veterinary surgeons and horse owners use a range of different thermometer types and models. One study on cows found a difference of up to 0.94°C between a glass mercury thermometer and a digital predictive thermometer [16]. It should be noted that the digital thermometer was being used by a student prior to any formal training, and training was shown to improve accuracy. Sousa et al. [34] found glass mercury and digital rectal thermometer readings differed by only 0.2°C in dogs when performed by an experienced operator. This difference is no greater than the limits of accuracy stated by most digital thermometer manufacturers. All three thermometers in this study were digital predictive thermometers, which should limit variability between devices.

The findings of this study suggest that existing equine temperature reference ranges (see table 1) are not necessarily appropriate for use in a general equine management setting. A particular concern is the upper limit of most published ranges, typically 38.5°C. Whilst the origin of these ranges is unknown, it is possible they were established within a veterinary setting, therefore introducing additional stressful factors that could have elevated the horses' temperatures. Increasingly, horse owners and yard managers are being advised to routinely monitor their horses' temperature to facilitate early detection of fever as part of a biosecurity programme [35]. The results of this study would suggest that using the previously reported reference ranges would result in mild hyperthermia going undetected. Therefore, establishing yard specific normal temperature ranges would enable horse owners to better interpret their horses' temperatures, improving equine biosecurity and welfare. The results of additional yard specific temperature reference ranges may suggest the need to re-evaluate the existing normal equine rectal temperature reference range.

5. Conclusion

This study reports the reference range for normal equine rectal temperature when measured with a digital rectal thermometer at a depth of 5cm, for one UK equine yard. The normal range was found to be 36.0 – 38.0°C (90% confidence interval [CI] = 35.97–36.03°C at the lower limit, CI = 37.97–38.03°C at the upper limit). Previously suggested normal temperature ranges were unsubstantiated, meaning their validity could not be confirmed for use clinically or for biosecurity purposes. The existing published reference ranges were not representative of the horses on this specific yard. Therefore, further research investigating potential variation in normal equine temperature in different management settings is recommended.

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