Comparison of axillary and rectal temperatures for healthy Beagles in a temperature- and humidity-controlled environment

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OBJECTIVE
To compare axillary and rectal temperature measurements obtained with a digital thermometer for Beagles in a temperature- and humidity-controlled environment.

ANIMALS
26 healthy Beagles (17 sexually intact males and 9 sexually intact females).

PROCEDURES
Dogs were maintained in a temperature- and humidity-controlled environment for 56 days before rectal and axillary temperatures were measured. Axillary and rectal temperatures were obtained in triplicate for each dog by use of a single commercially available manufacturer-calibrated digital thermometer.

RESULTS
Mean rectal and axillary temperatures of Beagles maintained in a temperature- and humidity-controlled environment were significantly different, with a median ± SD difference of 1.4° ± 0.15°C (range, 0.7° to 2.1°C). Mean rectal and axillary temperatures were 38.7°C (range, 37.6° to 39.5°C) and 37.2°C (range, 36.6° to 38.3°C), respectively.

CONCLUSIONS AND CLINICAL RELEVANCE
Results of this study indicated that the historical reference of a 0.55°C gradient between rectal and axillary temperatures that has been clinically used for veterinary patients was inaccurate for healthy Beagles in a temperature- and humidity-controlled environment. Rectal and axillary temperatures can be measured in veterinary patients. Reliable interpretation of axillary temperatures may accommodate patient comfort and reduce patient anxiety when serial measurement of temperatures is necessary. Further clinical studies will be needed. (*Am J Vet Res* 2015;76:632–636)

Body temperature is one of the primary vital parameters (temperature, pulse, and respiration) obtained during the initial physical evaluation of veterinary patients. The reference range for core body temperature in dogs is 37.2° to 39.2°C.[1–3] Clinically, rectal temperatures are typically obtained and generally considered to be representative of core body temperature. Investigators of 1 study[4] in humans found that rectal temperature measurement was less accurate than oral or tympanic thermometry for prediction of core body temperature. However, many other studies[5–8] of humans support rectal temperature measurement as a good indicator for core temperature yet reject it for its invasiveness and safety issues such as the potential for thermometer breakage and rectal perforation.

For similar safety and comfort reasons, axillary temperature measurement is often necessary for fractious animals, for animals with severe perianal discomfort or trauma, or for instances when serial measurement of temperatures is necessary. Investigators for a study[9] of humans suggest that axillary temperature is an acceptable surrogate for assessment of core body temperature. Nevertheless, axillary temperature represents body surface temperature, and to the authors' knowledge, the reliability of comparison between axillary and rectal temperatures has not been assessed in veterinary patients in a controlled environment. Authors of a recent veterinary report[10] describe comparison of axillary and rectal temperatures in dogs at the time of admission to an emergency service. Variables accounted for in that report[10] include body condition score, coat length and density, heart rate, mucous membrane color, capillary refill time, pulse quality, mentation, blood pressure, lactate concentration, reason for evaluation, and the presence of shock.

Numerous studies[11–21] of humans have been conducted to compare auricular, axillary, rectal, pulmonary arterial, and body surface temperatures in a variety of environmental settings in an attempt to determine a clinical standard for temperature measurement. In humans, there are concerns about a lag time between changes in rectal and core body temperature as well as the effect body composition has on temperature measurement.[22,23] Veterinary studies[24–30] conducted to compare rectal, auricular, subcutaneous temperature-sensing microchip, infrared thermometer, and pulmonary arterial temperatures have also been performed. Commercially available digital thermometers typically are used clinically for measurement of both rectal and axillary temperatures. A generalization of a 0.55°C gradient between axillary and rectal body temperatures when digital thermometry is used in humans has been assumed; however, investigators of some studies[31,32] of humans have questioned this agreement. In addition, no veterinary study has validated this claim. In both human and veterinary patients, repeatability among temperature measurement techniques is paramount, given that this can limit the amount of agreement between 2 methods if 1 is poorly repeatable.[33] The purpose of the study reported here was to determine the absolute difference between axillary and rectal temperatures for Beagles in a temperature- and humidity-controlled environment with temperatures measured by use of a commercially available digital thermometer. We hypothesized that axillary temperatures would be lower (by at least 0.55°C) than rectal temperatures. The authors also sought to subjectively assess tolerance of dogs to measurement of rectal and axillary temperatures. We hypothesized that measurement of rectal temperature would not be as well tolerated as measurement of axillary temperature.

Materials and Methods

Dogs

Twenty-six Beagles (17 sexually intact males and 9 sexually intact females) that were part of a privately owned research colony were enrolled in the study. Median age was 3.5 years (range, 1.5 to 6.0 years). Median body weight was 9.2 kg (range, 8.1 to 10.7 kg). All dogs appeared to be of an appropriate body condition score (approx 5 or 6 on a scale of 1 to 9); however, this was not specifically assessed for each dog. All dogs were deemed healthy on the basis of results of a physical examination performed by the investigators and confirmation by an overseeing preclinical veterinary supervising clinician. Informed consent for use of the dogs was provided by the owners. The study protocol was approved by the Colorado State University Animal Care and Use Committee and was compliant with American College of Laboratory Animal Medicine guidelines as well as Colorado State University guidelines for research animals.

Procedures

Dogs were maintained in a temperature- and humidity-controlled environment. Ambient temperature was maintained between 21.1° and 22.2°C, and ambient humidity was held within the range of 22% to 27%. Dogs were maintained in this controlled environment for 56 days before rectal and axillary temperatures were measured.

Rectal and axillary temperatures were obtained concurrently in triplicate from each dog. Axillary and rectal temperatures were measured with a commercially available digital thermometer[a] at a single time point during the study. The digital thermometer was calibrated for accuracy by the manufacturer via water bath to within 0.11°C between 35.5° and 41.6°C at room temperature (21.6°C).

Rectal temperatures were obtained with the thermometer probe inserted into the rectum to a depth of approximately 0.5 cm and pressed against the rectal mucosa to avoid intrafecal temperature measurements. Axillary temperatures were obtained from the left axillary region with the same digital thermometer immediately after rectal temperature measurement. Each temperature reading was obtained within 8.0 seconds after insertion into the anatomic location. Triplicate rectal and axillary temperatures for each dog were obtained within a period of 3 to 5 minutes during the study, which was conducted over a period of approximately 3 hours. Dogs were subjected to a minimal amount of handling to avoid increases in body temperature attributable to stress or anxiety.

Statistical analysis

Sample size was determined by use of a power calculation (with an SD of ± 1.0, α of 0.05, and β of 0.20) for a paired t test to detect an expected difference of 0.55°C between rectal and axillary temperatures of dogs. Results of the power calculation (power > 95%) indicated a study population of 25 dogs was needed. Descriptive statistics (mean, median, and SD) were calculated for all measurements by use of commercially available statistical software.[b] The Shapiro-Wilk test was used to assess normality of continuous variables. Spearman correlation coefficients were calculated to assess correlation between mean axillary and mean rectal temperatures as well as intermeasurement agreement for each site. Temperature data, specifically rectal temperature, were not normally distributed; therefore, the Wilcoxon signed rank test was used to compare differences between mean rectal and mean axillary temperatures. Values of $P \leq 0.05$ were considered significant.

Results

Temperature readings were obtained in triplicate for axillary and rectal measurements (156 temperature evaluations), and mean values were calculated. For each dog, mean axillary and rectal temperatures as well as the difference among means for the 2 anatomic locations were summarized. Given that a portion of the data were not normally distributed, mean values were compared by use of nonparametric analysis to detect significant differences. Mean ± SD rectal and axillary temperatures were 38.72 ± 0.37°C (range, 37.61° to 39.50°C) and 37.33 ± 0.51°C (range, 36.61° to 38.33°C), respectively. Median rectal temperature was significantly ($P < 0.001$) higher by 1.4 ± 0.15°C (range, 0.7° to 2.1°C), compared with the mean axil-

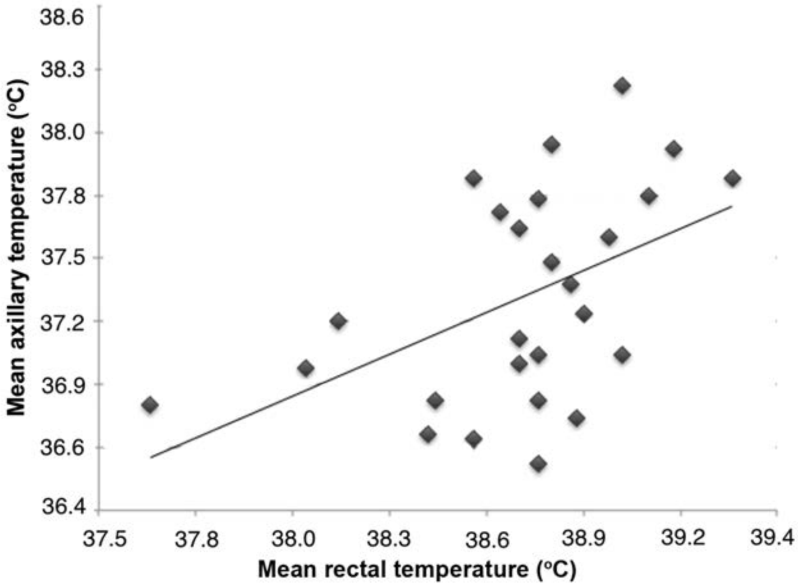

Figure 1—Scatterplot of paired mean rectal and axillary temperatures for 26 healthy Beagles in a temperature- and humidity-controlled environment. Each diamond represents results for 1 dog; results represent the mean of 3 measurements for each anatomic location in each dog. The line of best fit is indicated and revealed very poor correlation (R^2 = 0.24) between mean rectal and axillary temperatures.

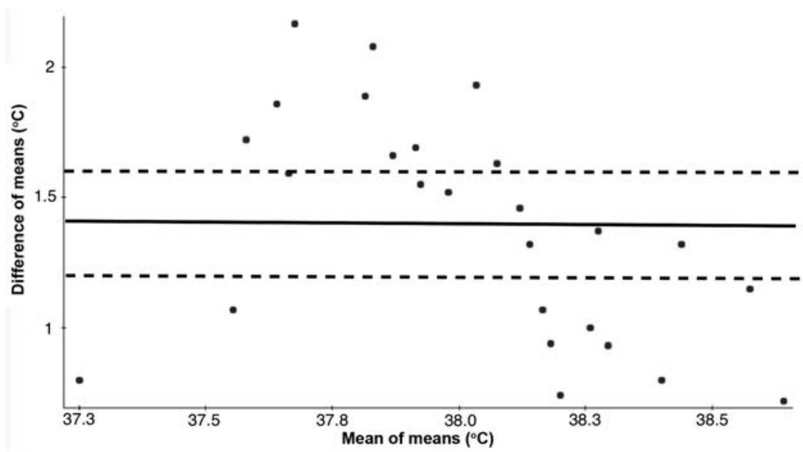

Figure 2—Scatterplot of the difference between mean rectal and axillary temperatures versus the mean of the mean axillary and rectal temperatures for 26 Beagles in a temperature- and humidity-controlled environment. Each circle represents results for 1 dog; results represent the mean of 3 measurements for each anatomic location in each dog. The solid horizontal line represents the mean difference, and the dashed lines represent ± 2 SD (the value for the mean difference ± 2 SD was 1.38 ± 0.43°C).

lary temperature. For all dogs, axillary temperature was always lower than rectal temperature (positive mean difference between rectal and axillary temperatures). There was very poor correlation (R^2 = 0.24) between mean rectal and axillary temperatures **(Figure 1)**. Interestingly, a smaller mean difference was apparent at higher body temperatures, compared with the mean difference at lower body temperatures, for all dogs **(Figure 2)**.

Intermeasurement and mean temperature measurement R^2 exceeded 0.87, except for the third axillary temperature measurement (R^2 = 0.70), which had a median difference of 0.22°C from the median for the first measurement. There was also a nonsignificant increase of 0.22°C in axillary temperature between the first and third measurements, compared with the mean value for all 3 measurements.

Subjectively, dogs appeared more tolerant of axillary temperature measurements than of rectal temperature measurements. Of note was the fact that no dog appeared unduly stressed during handling and temperature measurements.

Discussion

Core body temperature is considered the criterion-referenced standard for comparison with all other temperature-measuring modalities in humans and other animals.[34,35] However, invasiveness involved with attaining a core body temperature often precludes its use in clinical medicine. Rectal temperature is most often assessed clinically as a proxy for core body temperature. In humans, it is suggested that rectal temperature can be estimated by adding 0.55°C to the temperature measured at the axilla.[31,32] Furthermore, an established gradient between rectal and axillary temperatures in dogs was reported as –1.3° to 2.3°C.[10] For that particular study population of dogs, most (60/94 [64%]) had an axillary temperature within 0.55°C of the rectal temperature.[10] In the present study, 2 methods for assessing body temperature in dogs were compared for agreement of results and evaluated on the basis of the historical extrapolation of a difference of 0.55°C between rectal and axillary temperatures in humans.

In dogs, temperature measured by use of rectal thermometry has had the best agreement with core body temperature, compared with temperature measured with a pulmonary arterial catheter or by other methods such as auricular thermometry and a subcutaneous temperature-sensing microchip.[30] To the authors' knowledge, a standardized comparison of temperatures obtained with rectal thermometry and temperatures obtained from the axilla in dogs in a temperature- and humidity-controlled environment has not been performed. In a study[31] of humans in which investigators compared rectal and axillary temperatures, the pooled mean difference between these 2 anatomic locations was 0.17°C (range, 0.15° to 0.50°C) for neonates and

0.92ºC (range, 0.15º to 1.98ºC) for older children and young adults. In another study[29] of 3 thermometry devices and microchip locations in dogs, the smallest difference between core body temperature and temperature measurements by use of those methods was achieved with a rectal thermometer; 280 of 297 (94.3%) rectal temperature measurements were within 0.5ºC of the core body temperature measured by use of a pulmonary arterial catheter. In the present study, a median difference of 1.4ºC (range, 0.7º to 2.1ºC) was found between rectal and axillary temperatures in healthy Beagles in a temperature- and humidity-controlled environment.

The nonsignificant increase of 0.22ºC in axillary temperature between the first and third measurements, compared with the mean value for all 3 measurements, may be explained temporally because the third measurement was the final temperature measurement obtained for each dog and could have reflected an increase in body temperature attributable to handling or excitement. However, this increase was considered clinically irrelevant. An interesting observation for the present study was that there apparently was better agreement of mean axillary and rectal temperatures for higher body temperatures. This may further support the use of axillary temperatures for febrile, critically ill animals; however, additional investigation into this finding is warranted.

Digital thermometers involve equilibrium or predictive thermometry. In equilibrium thermometry, the thermometer makes direct contact with the body, and a thermistor uses electrical resistance to compute body temperature.[30] In predictive thermometry, a thermometer is placed in contact with the body, and the rate of temperature change then is measured and used to algorithmically predict the final temperature. Both methods appear to be accurate means of obtaining body temperature. In the present study, we used a commercial thermometer that provided results for predictive thermometry.

Given the commonality, noninvasiveness, and accessibility of axillary temperature measurements, an accurate method for their interpretation in dogs is essential. Clinical decisions regarding active cooling or warming, antimicrobial treatment, and further diagnostic testing may be made on the basis of a perceived body temperature. Axillary temperatures are typically lower than rectal temperatures, which provide the potential to miss mild hyperthermia or fever in some patients. In addition, diagnostic testing in animals with fever of unknown origin can be stressful for the patient and may also be expensive for the owner. Accurate interpretation of axillary temperatures could offer an effective, noninvasive, and minimally discomforting method for assessment of body temperature as well as provide suitable in-hospital monitoring and clinician guidance.

A limitation of the present study was the lack of assessment of clinical variables known to influence body temperature in dogs. Vital parameters, body condition score, and other markers of perfusion that would have provided additional valuable information were not assessed. The decision to use Beagles was intended to provide standardization of the study population to mitigate confounding factors such as coat length and body surface area. The authors acknowledge that there is vast diversity in veterinary patient populations and advise caution with regard to extrapolation of the results reported here to clinical cases. A temperature- and humidity-controlled environment was chosen to alleviate confounding factors such as ambient temperature and humidity, which can affect body temperature. Findings of this study were considered representative of the difference between rectal and axillary temperatures in a single breed of dog while accounting for constant ambient temperature and humidity. Further studies to clinically evaluate rectal and axillary temperatures in dogs that account for changes in ambient temperature and humidity as well as other patient and clinical factors are needed to establish guidelines for interpretation of axillary temperatures.

Footnotes

a. Vick's ComfortFlex digital thermometer, Kaz Inc, Proctor and Gamble Co, Cincinnati, Ohio.

b. Statcrunch, Integrated Analytics LLC and Pearson Education, New York, NY. Available at: www.statcrunch.com. Accessed Oct 26, 2012.

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