NOTE

Physiology

Daily Rhythmicity of Body Temperature in the Dog

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ABSTRACT. Research over the past 50 years has demonstrated the existence of circadian or daily rhythmicity in the body core temperature of a large number of mammalian species. However, previous studies have failed to identify daily rhythmicity of body temperature in dogs. We report here the successful recording of daily rhythms of rectal temperature in female Beagle dogs. The low robustness of the rhythms (41% of maximal robustness) and the small range of excursion (0.5°C) are probably responsible for previous failures in detecting rhythmicity in dogs.

KEY WORDS: canine, circadian rhythms, rectal temperature.


Circadian rhythmicity is a pervasive property of mammalian physiology. A circadian pacemaker located in the suprachiasmatic nuclei of the hypothalamus is responsible for an oscillatory process that is expressed in practically every function in the body [9, 19]. In the dog, daily rhythmicity has been demonstrated in a variety of physiological functions, such as heart rate, blood pressure, respiratory rate, bone metabolism, heat dissipation, and rest/activity [2, 3, 5, 7, 11]. In most cases, no attempt was made to demonstrate that these rhythms are truly endogenous—that is, that they are not only nycthemeral rhythms but also circadian rhythms. Except for transient feeding-related elevations, at least three research groups have failed to identify even a daily (nycthemeral) rhythm of body temperature in dogs maintained under a light-dark cycle [4, 6, 8]. Here we report the successful recording of daily rhythms of rectal temperature in Beagle dogs.

Dogs (Purebred Beagle) were obtained from the canine breeding facility at the University of Messina (Italy). Seven female dogs (mean body mass: 10 kg) were used. They were housed in individual pens (140 × 200 cm) lined with wood shavings and were fed Kieper dog food once a day (4 hr after lights-on) and water ad libitum. Lights were on for 12 hr each day (600 lux from 0600 to 1800 hr). Ambient temperature was thermostatically maintained at 21 ± 2°C. Rectal temperature (3 cm deep) was recorded every 2 hr with an electronic thermometer (Model HI-92740, Hanna Instruments, Bedfordshire, UK) for 8 consecutive days.

The first day of data was discarded, and the following 7 days were used for analysis of rhythmic parameters: rhythm robustness, mean level, range of excursion, and acrophase (i.e., the time associated with the daily peak). Rhythm robustness refers to the regularity of the oscillatory process (i.e., how strongly the oscillations deviate from mere random variation). The robustness of the daily rhythm was determined by the chi square periodogram [18]. The periodogram’s QP statistic (for P=24 hr) was calculated for each individual using the 7 days of data (84 data points). For data sets of this size, a perfect wave (such as a mathematically generated cosine wave) produces a QP value of 84. Thus QP values were expressed as a percentage of 84, which represents a perfectly stable wave form. QP values above 23% of maximal robustness are statistically significant at the 0.05 level, and values above 29% are significant at the 0.01 level. Although the chi square periodogram procedure was originally developed for data sets collected in hourly intervals [18], we have previously validated its use in data sets with either higher [15] or lower [14] resolution.

The mean level of the body temperature rhythm was computed as the arithmetic mean of the 12 daily measurements (2-hr bins) for each individual. Likewise, the range of excursion was computed as the difference between the highest and the lowest temperature each day for each animal. The acrophase of the rhythm was calculated by the fitting of a family of cosine waves to each daily segment of the rhythm. The time of day corresponding to the peak of the best-fitting wave was taken as the acrophase [10].

All animals showed robust daily rhythmicity in body temperature with QP values above the 0.01 significance level. Representative records for one animal are shown in Fig. 1. In this animal, as in all other animals, body temperature ascended very gradually during lights-on and reached the daily summit at the time of lights-off each day.

The mean daily values for all animals are shown in Fig. 2. Although body temperature started its daily rise immediately after feeding (arrow), the daily peak was not reached until the time of lights-off, 8 hr later. Thus, although diet-induced thermogenesis (the thermal effect of feeding) may have contributed to the initial rise in body temperature, it cannot account for the full daily oscillation.

The mean robustness of the rhythm (± SEM) for the 7 dogs over the 7 days was 40.6 ± 1.8 % of maximal robustness, which is small when compared with that of a variety of other mammalian species [12, 16] but still above the significance level (23% of maximal robustness). The mean acrophase (computed separately for each dog) was 17.2 ± 0.4 hr, which indicates that the peak of the daily oscillation of body temperature was achieved approximately 11 hr after
lights-on, or 1 hr before lights-off, which is consistent with the mean curve of body temperature seen in Fig. 2. The mean level of the body temperature rhythm was $39.13 \pm 0.01^\circ C$. This value is about 1 $^\circ C$ higher than that found in the previous studies that failed to identify non-feeding-induced daily rhythmicity [4, 6, 8]. However, the average rectal temperature of the dog is considered to be $38.9^\circ C$ [1], which is only 0.2 $^\circ C$ lower than the value we obtained. The mean range of excursion in our study was $0.51 \pm 0.01^\circ C$.

These results allow the addition of dogs to the extensive list of mammals that display a daily rhythm of body temperature [17]. Our dogs exhibited statistically significant daily rhythmicity in a constant thermal environment, and the daily rise in body temperature was not caused by feeding. The low robustness of the rhythm (41% of maximal robustness) and the small range of excursion (0.5 $^\circ C$) are probably responsible for previous failures in detecting rhythmicity in dogs. When a weak rhythm is studied, noise introduced by extraneous variables can easily mask the rhythmicity. Uncontrolled variations in ambient temperature or illumination can induce physiological responses that affect body temperature. Also, group-housed animals are likely to be disturbed by interactions with neighbours, and individually-housed animals kept in a busy animal colony with frequent visits by animal caretakers are likely to be disturbed as well. Although monitoring of body temperature by telemetry can eliminate disturbance caused by the experimenters themselves, it can not eliminate disturbance caused by other extraneous variables. We were not involved in the three previous studies that failed to identify a daily rhythm of body temperature in dogs [4, 6, 8], but we believe that a rhythm would have been found if extraneous variables had been effectively eliminated. As we have indicated elsewhere, various studies in sheep and swine without proper control of extraneous variables failed to identify a daily rhythm of body temperature, whereas studies with proper control of extraneous variables identified moderate to robust rhythmicity [13].

REFERENCES