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TELEMETRIC MEASUREMENT OF CORE TEMPERATURE IN PHARMACOLOGICAL RESEARCH: VALIDITY AND RELIABILITY

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Abstract

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1. The authors present data establishing the reliability and validity of a method for telemetrically measuring core temperature.
2. The method is designed to be of particular utility to psychobiological researchers.

Keywords: telemetry, temperature

Abbreviations: intraperitoneally (ip), minute (min)

Introduction

Regulation of core temperature is sensitive to many psychobiological manipulations (Dilsaver et al, 1986, 1987; Dilsaver and Alessi, 1987; Dilsaver, 1990). The purpose of this article is to demonstrate the reliability and validity of a biotelemetric method of measuring core temperature in laboratory animals. This method is designed to be of utility in psychobiological research.

Material and Methods

Animals

Five adult, male Sprague-Dawley rats (mean weight $\pm$ SEM = 359.6 $\pm$ 12.6 g) were used in this study.

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Drugs

Clonidine is an α_2-adrenergic agonist. It preferentially acts at presynaptic auto receptor sites at the doses used in the study reported here.

Apparatus

The Model VM Mini-Mitter (Mini-Mitter Co, Sunriver, OR) is a biotelemetric thermosensor which emits Hertzian waves, detectable with a standard AM receiver, at a rate directly proportional to temperature.

Calibration of Instruments

Ten (10) Model VM Mini-Mitters were calibrated by measuring their emission rates in a Model 50 Precision water bath set for 34°C, 35°C, 36°C, 37°C, and 38°C. Each investigator measured the time to emit 10 sounds using a digital display stopwatch (Fisher Scientific, Model 14-649-5) until they obtained 4 measurements within 0.04 seconds of one another. These measurements were then averaged. This yielded 5 pairs of time ("X" variable) and temperature ("Y" variable). Two linear regression equations were calculated. The first equation was based on the emission rate of the instruments at 34°C, 36°C, and 38°C. The second set of equations was based on their emission rates at 34°C, 35°C, 36°C, 37°C, and 38°C. Table 1 lists the regression equations based on the emission profiles of each instrument at both 3 and 5 temperatures. The slopes of the regression equations are directly proportional to change in temperature per unit time. The slopes are statistically indistinguishable for all 10 instruments based on calibration using both 3 and 5 temperature points. This was determined by overlap of the 95% confidence intervals for each slope.

Mini Mitter Implantation and Experimental Procedure

Mini-Mitters were surgically implanted into the peritoneal cavity of 5 adult, male Sprague Dawley rats (mean weight ± SEM = 359.6 ± 12.6). The animals were allowed 5 days to recover before conducting the experiment. Two investigators (Dilsaver and Majchrzak) measured the time to emit 10 sounds prior to the injection of clonidine HCl, 0.10 mg/kg ip. This provided the baseline core temperature for each animal. Core temperature (time to emit 10 sounds) was measured every 5 minutes for 120 minutes following the injection of clonidine. Change in core temperature relative to baseline was calculated by subtracting temperature at baseline from temperature at each of the 24 time points.

Statistical Analysis

Data were analyzed using the Wilcoxan sign Rank Test for matched pairs and Student's paired t-test. All measures of variance in the text refer to the standard error of the mean (SEM).

Results

Results of Experiment Based on the Calibration of Mini-Mitters Using 5 Temperatures: The mean decrease in core temperature over the course of the experiment as measured by Majchrzak and Dilsaver were -1.28 ± 0.21 and -1.22 ± 0.22 (mean ± SEM), respectively. These do not differ ($p = 0.57$, $t = 0.61$, $df = 4$, paired t-test).

Results of Experiment Based on the Calibration of Mini-Mitters Using 3 Temperatures: Majchrzak and Dilsaver obtained mean decreases in core temperature of -1.26 ± 0.21 and -1.24 ± 0.23°C, respectively, using regression equations calibrated at 3 temperatures (34°C, 36°C, an 38°C). These means do not differ ($p = 0.19$, $t = 0.86$, $df = 4$, paired t-test).

Results of Experiment Based on the Calibration of Mini-Mitters Using 3 and 5 Temperatures: Majchrzak obtained a mean decrease of -1.26 ± 0.20°C using a regression equation calibrated to 3 temperatures and Dilsaver a mean reduction of -1.22 ± 0.22°C using a regression equation calibrated to 5 temperatures. These did not differ ($p = 0.72$, $t = 0.39$, paired t-test). Majchrzak obtained a mean decrease of -1.28 ± 0.21°C using a regression equation calibrated to 5 temperatures and Dilsaver a mean reduction in core temperature of -1.24 ± 0.23°C using the regression equation calibrated to 3 temperatures. These did not differ ($p = 0.72$, $t = 0.39$, paired t-test).

Internal Consistency of Investigators: SCD obtained mean decreases in core temperature of -1.24 ± 0.23 and -1.22 ± 0.22°c using regression equations calibrated to 3 and 5 temperatures, respectively ($p = 0.37$, $t = 1.0$, paired t-test). Majchrzak obtained mean decreases in core temperature of -1.26 ± 0.20 and -1.28 ± 0.21°C using regression equations calibrated to 3 and 5 points, respectively. These did not differ ($p = 0.37$, $t = 1.0$, paired t-test).

Table 1

Comparison of Linear Regression Equations Derived by Independent Investigators of 10 Mini-Mitters

MM	Majchrzak's Equations A*	Dilsaver's Equations A*	Slopes Signif. Different	Majchrzak's Equations B**	Dilsaver's Equations B**	Slopes Signif. Different
1	y=57.01-5.24(x)	y=57.38-5.45(x)	No	y=57.81-5.39(x)	y=58.66-5.73(x)	No
2	y=57.22-5.86(x)	y=55.40-5.56(x)	No	y=57.10-5.77(x)	y=55.18-5.48(x)	No
3	y=59.20-5.83(x)	y=57340-5.39(x)	No	y=58.74-5.68(x)	y=58.04-5.57(x)	No
4	y=55.18-4.80(x)	y=55303-4.87(x)	No	y=55.99-4.99(x)	y=55.97-5.09(x)	No
5	y=55.74-5.10(x)	y=55.10-5.03(x)	No	y=55.87-5.12(x)	y=55.98-5.21(x)	No
6	y=58.07-4.44(x)	y=57.31-4.50(x)	No	y=58.24-4.47(x)	y=57.02-4.44(x)	No
7	y=55.66-5.05(x)	y=54.29-4.86(x)	No	y=55.55-5.03(x)	y=54.10-4.79(x)	No
8	y=55.75-4.52(x)	y=53.82-4.21(x)	No	y=56.37-4.65(x)	y=54.07-4.28(x)	No
9	y=54.97-4.36(x)	y=55.80-4.71(x)	No	y=55.19-4.41(x)	y=57.62-5.14(x)	No
10	y=55.57-3.74(x)	y=54.01-3.49(x)	No	y=54.85-3.60(x)	y=53.98-3.48(x)	No

Legend:

* with 5 temperatures
** with 3 temperatures

The Mini-Mitters used in this study emit amplitude modulated (AM) radio waves at a rate directly proportional to temperature. The emission of each wave is perceptible as a distinct sound when the AM receiver of a transistor radio is used. The relationship between temperature and the rate of emission of the AM waves is mathematically described by a linear regression equation in which "y" is absolute temperature and "x" is rate of emission of the pulses.

The investigators calibrated 10 Mini-Mitters. The thermosensor within the Mini-Mitter is sufficiently sensitive, precise, and reliable in its function and the technique of each investigator sufficiently similar that the derivation of linear regression equations based on the emission rate of each instrument in a temperature controlled water bath at either three or five temperatures overlapping with the expected core temperature of a healthy rat are statistically identical. The investigators independently derived linear regression equations with statistically identical slopes when they calibrated the Mini-Mitters using both three and five temperatures. Thus, the equations from their calibration of the instruments yield identical measurements of change in core temperature.

Discussion

This study demonstrates that independent investigators can obtain statistically equivalent calibrations of the Model VM Mini-Mitter by measuring the emission profile of the instruments at 3 or 5 temperatures. Further, it was possible to obtain statistically indistinguishable results by measuring the time required to emit 10 sounds every 5 minutes in an experiment in which rats were challenged with clonidine HCl, 0.10 mg/kg ip. Finally, calibration of the devices based on the consideration of 3 and 5 points yielded identical results.

Others use the Model VM Mini-Mitter to conduct physiological studies. The authors adapted the method to render it useful in assessing pharmacological effects on core temperature. These experiments require frequent measurements in large numbers of animals. In order to carry out these studies, it is necessary to measure the time to emit 10 rather than 50 sounds, as has been the practice of physiologists (Tocco-Bradley et al, 1985). This study indicates that it is possible to obtain useful and reliable data by measuring the time required to emit 10 sounds. Consequently, the Model VM Mini-Mitter can be employed in psychobiological experiments requiring the measurement of core temperature in large numbers of animals at 5- to 10-min intervals.

Conclusions

The authors demonstrated that two independent investigators (Dilsaver and Majchrzak) can reliably calibrate these instruments by measuring their emission rates in a temperature controlled water bath at 3 (34°C, 36°C, and 38°C) and 5 (34°C, 35°C, 36°C, 37°C, 38°C) temperatures. Also the authors demonstrated that the two investigators obtain statistically identical results using instruments calibrated to both 3 and 5 points, in an experiment in which the thermic response to clonidine, 0.10 mg/kg ip, is measured in rats.

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