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Automated monitoring of resting in dogs

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ABSTRACT

Dogs may be deprived of adequate rest in certain environments such as noisy shelters or kennels. Accelerometers have been used to assess gross activity in dogs, but do not appear to distinguish simple inactivity from the prone, head-down recumbency that typifies sustained rest in the species. We tested the use of collar-mounted data loggers that record changes in tilt in 3 dimensions for monitoring head-down recumbency. Twelve dogs were studied using both video-recording and data loggers for a total of 36 h, with behaviour recorded every 10 s. From the video-recordings, dogs were coded as "resting" during a given minute if they were in head-down recumbency on all six observations in the minute, or "active" otherwise. With the criterion that rest was indicated when mean tilt change in a minute was $\leq 10^{\circ}$, the data loggers correctly identified active and resting minutes in 87 ± 2 per cent (mean $\pm$ SE) of minutes recorded. Thresholds of 8 and 12° were nearly as accurate whereas the other thresholds tested (2, 4, 6 and 14°) were less accurate. For two dogs the accuracy was lower (70 and 79%) because their unusual restless movements while recumbent often exceeded the 10° threshold. Receiver Operating Characteristic (ROC) analysis also showed the best performance (Sensitivity 0.88, Specificity 0.81) at a 10° threshold. We conclude that the tilt feature of the collar-mounted data loggers provides a reasonably accurate and efficient means of identifying head-down recumbency in domestic dogs but accuracy is reduced in dogs that are unusually restless while recumbent.

1. Introduction

Lack of rest may be an animal welfare problem in dog shelters where dogs commonly encounter many causes of stress (Hennessy et al., 1997). An efficient means of monitoring rest could therefore be of value for research or shelter management.

Insight into the physical activity of domestic dogs has been made possible by automated measurement. Pedometers can provide a reasonably accurate indication of physical activity in dogs by measuring the number of steps taken (Chan et al., 2005), and accelerometers on the dog's collar have been used to monitor spontaneous activity of dogs in homes (Hansen et al., 2007). In one study, harness-mounted accelerometers detected changes in the speed of dogs on a treadmill but not changes in energy expenditure when the grade was increased (Preston et al., 2012). Collar-mounted accelerometers have also been used to distinguish between active and sedentary behaviour (Yam et al., 2011; Michel and Brown, 2011). As other variations, Cheung et al. (2014) compared the use of uni-axial and tri-axial accelerometers to monitor gross motor activity in dogs, and Gerencsér et al. (2013) used a tri-axial inertial sensor to recognize different types of behaviour in moving dogs.

A feature of sustained rest in dogs is the recumbent position of the head similar to the characteristic sleeping posture, "with hind legs tucked up and their heads turned caudolaterally" (Houpt, 2011, page 68). Sustained head-down recumbency is not, however, distinguished by most accelerometers as they rely on detecting acceleration (*g*-force) values.

However, the HOBO Pendant G Data Logger (Onset Computer Corporation, Bourne, MA) – a tri-axial accelerometer – provides the option of recording degrees of tilt, a feature that has been used successfully in the automated detection of recumbency in dairy cows (Ito et al., 2009). This study explored the use of this feature of the HOBO Data Logger as a means of monitoring head-down recumbency in dogs and thus replacing the need for time-consuming human observation.

The objectives of this study were: (1) to test the usefulness of a collar-mounted device to monitor head-down recumbency in dogs and (2) to identify the tilt threshold that optimizes the accuracy of the data. For the latter, we reasoned that low tilt thresholds would yield false negatives because slight movements during rest would be mis-identified as activity, whereas high thresholds would yield false positives because some genuine activity would not be

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Table 1
Dog demographics, the number of minutes coded as resting or active from the video recordings, and the percentage of minutes correctly coded by the data logger at 10° tilt threshold.

Breed	Age*	Location	Sex**	Minutes coded from video recordings		% Coded correctly at 10° tilt
				Resting	Active	
Shih Tzu	Young adult	Shelter	M/N	20	124	97
German Shepherd Dog	Young adult	Home	M/N	152	49	97
Pug	Adult	Home	M/N	94	96	93
Beagle Mix	Adult	Home	M/N	39	173	91
Border Collie	Senior	Home	F/S	200	32	91
Labrador Retriever Mix	Adult	Shelter	M/N	41	63	89
Welsh Corgi Mix	Senior	Home	M/N	132	91	88
German Shorthair Pointer	Adult	Shelter	F/S	75	47	87
Doberman	Pup	Shelter	M/N	32	145	83
Border Collie	Adult	Home	F/S	148	51	81
Basset Hound	Pup	Shelter	F/S	95	97	79
Pit Bull Mix	Young Adult	Shelter	M/N	133	39	70

* Pup < 1 year; young adult 1–2 years; adult 2–7 years; senior > 7 years.
** M/N—male/neutered; F/S—female/spayed.

detected. We therefore used a range of thresholds to identify an intermediate value where accuracy would be maximized.

2. Materials and methods

2.1. Data loggers

The study used the HOBO Pendant® G Data Logger ("data logger"), a tri-axial accelerometer with a durable, hard plastic casing measuring 58 × 33 × 23 mm and weighing 18 g. The data logger is capable of collecting both acceleration and tilt data in all three axes as described by Moreau et al. (2009). Data collection is initialized and stopped using proprietary software, HOBOware®Pro, and data are downloaded as an Excel spreadsheet. Logging intervals can be set from 0.01 s to more than 18 h. Battery life ranges from 7 days to 1 year depending on the interval used for logging. The 64 K bytes of memory include approximately 21.8 K bytes of combined *x*-, *y*-, and *z*-axis readings (Onset Computer Corporation, 2012).

2.2. Animals

The study involved 14 dogs, seven of them owned dogs and seven held at the Langley Animal Protection Society, Langley, British Columbia. All dogs had been examined by a veterinarian within the year before the study and no health concerns were apparent. Nine were current or former shelter dogs; age and breed (mix) estimates were provided by shelter veterinary records (Table 1).

2.3. Data collection

Dogs were fitted with adjustable, lightweight nylon collars with quick-release snaps. Larger dogs wore custom-made collars with an outside elastic pocket to securely accommodate the data logger (Dog Sport Gear, Langley, British Columbia, Canada). Medium-sized and smaller dogs wore commercially available collars with data loggers held in position with tape.

For each recording session, the data logger was initialized to collect data at 10-s intervals. Local time (hour, minute, second), from the website timeanddate.com, was displayed on a laptop computer (HP G60 Notebook, Hewlett-Packard, Palo Alto, CA, USA). As verification that the data logger was functioning properly, the data logger was video-recorded in front of the laptop screen in several position changes for 1–2 min before being affixed to the dog's collar. The collar was placed on the dog's neck with the data logger in the dorsal position and then tightened so as to allow two fingers to be fitted between the collar and the dog.

For the period of data collection, each dog was placed individually in a portable exercise pen (91.4 cm × 61 cm) and video-recorded with a Camcorder (Panasonic HDC-TM41P/PC, Panasonic, Kadoma, Japan). All shelter dogs were recorded in the shelter with the exercise pen located in an office area where the dogs had previously received individual staff time and attention. Owned dogs were recorded in their homes with the exercise pen positioned in a room (kitchen or living room) where the owner felt the dog would be the most comfortable. The exercise pen was outfitted with comfortable bedding, a dish of water, and a familiar chew toy. The video camera was adjusted so that the dog and the laptop (still showing the time) were in view. Once video-recording commenced and the dog appeared to settle, the researcher left the study area, making periodic checks on the dog without attracting the dog's attention. Recording sessions ranged from 104 to 232 min depending on availability of the dog, and occurred between 10:00 and 16:00 h. At the end of each recording session, the data logger was stopped and the data were downloaded to an Excel 2010 spreadsheet.

Two dogs were withdrawn because of technical problems with the data logger or video recording, leaving 12 dogs that were video-recorded for a total of 2168 min (36 h).

2.4. Data analysis

For the analysis of the video recordings, an observer replayed each recording and noted whether the dog was in head-down recumbency with both the head and body down (i.e. supported only by the substrate) at each 10-s "time stamp" (the instant when the data logger recorded tilt) thus yielding six instantaneous observations per minute. For each minute, the dog was coded as "resting" if the head and body were down during all six observations making up the minute, or "active" if the head and body were not down during any of the six observations.

For the analysis of the data logger information, the change in tilt (degrees) between one time stamp and the previous time stamp (10 s before) was calculated for all time stamps for the *x*, *y* and *z* axes. Changes for the three axes were then summed, and the six sums in each 1-min segment were averaged. These averages were compared to thresholds of 2, 4, 6, 8, 10, 12 and 14°. For example, with a threshold of 2°, the dog was classified as active during a given minute if the average change for the minute exceeded 2°, or resting if the average change was 2° or less. These assessments of active versus resting were then compared to the video-recorded behaviour. The "percentage agreement" (the percentage of minutes in which the data logger agreed with the video data on whether the dog was resting or active) was calculated for each dog at each threshold of 2 to 14°.