USE OF 24-Hour AMBULATORY ELECTROCARDIOGRAPHY (HOLTER MONITORING) FOR ASSESSMENT OF HEART RATE VARIABILITY IN HEALTHY DOBERMAN PINSCHERS IN COMPARISION WITH A ROUTINE ECG AND PHYSICAL EXAMINATION

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ABSTRACT
In veterinary clinical practice, Holter monitoring has been used most frequently in dogs, often during evaluation for syncope or episodic weakness, but also for detecting intermittent arrhythmias, assessing response to antiarrhythmic drug therapy, and screening for subclinical cardiomyopathy of Boxers and Doberman Pinschers since routine ECGs detects frequent arrhythmias, but may have limited sensitivity in dogs with infrequent or intermittent arrhythmias, as they reflect only a very short period of day. However, no large study exists evaluating the use of a physical examination, routine ECG and comparing the results to the Holter recordings for assessing heart rate variability in Doberman Pinschers. The aim of this study was to evaluate and compare main heart rate parameters in clinically healthy Doberman Pinschers, obtained during physical examination, routine ECG and 24-hour Holter monitoring. Materials and Methods. Physical examination, routine ECG and 24 hour ECG recording results were evaluated in 11 clinically healthy, client-owned Doberman pincher dogs. Results. There was a significant difference between average heart rates obtained with three different methods. Mean heart rates obtained with routine ECG, were significantly higher ($p<0.001$) than those recorded using Holter monitoring. Minimum sinus RR interval was similar in all dogs, but there was a range in amplitude between maximum sinus RR intervals of all dogs. No ventricular premature complexes (VPCs) were found during routine ECG examination, while all dogs had at least one VPC over 24-hour period.
KEY WORDS: Doberman, 24-hour Holter monitoring, heart rate variability

INTRODUCTION
Ambulatory electrocardiography (Holter monitoring) has been used for over 30 years in people to assess cardiac arrhythmias, effectiveness of antiarrhythmic therapy, ischemic S-T segment changes, and other parameters over prolonged periods of time (e.g., 24 to 72 hours) and during normal daily activities. Holter monitoring allows more accurate evaluation of antiarrhythmic drug effectiveness than routine, intermittent electrocardiograms (ECGs) because arrhythmia frequency naturally fluctuates widely over time (Bleifer et al. 1980, Kennedy 1992, Zipes 1997). In veterinary clinical practice, Holter monitoring has been used most frequently in dogs, often during evaluation for syncope or episodic weakness, but also for detecting intermittent arrhythmias, assessing response to antiarrhythmic drug therapy, and screening for subclinical cardiomyopathy of Boxers and Doberman Pinschers (Calvert 1991, Calvert 1995, Goodwin, Cattiny 1995, Goodwin et al. 1992, Moise, DeFrancesco 1995, Rush, Keene 1989) since routine ECGs, detects frequent arrhythmias, but may have limited sensitivity in dogs with infrequent or intermittent arrhythmias, as they reflect only a very short period of day (Marino et al., 1994).
Holter examinations are not as readily available to the veterinarian, and are more expensive and time consuming to perform than routine ECGs. Routine ECG, however, reflect electrical activity of the heart only for a very short period of time that might not be objective enough for

evaluation of heart rate variability and arrhythmia detection over a 24-hour period. One study in Boxer dogs showed that a routine ECG is specific, but not sensitive enough for screening purposes and therapeutic evaluations in mature Boxers with ventricular arrhythmic disease (Meurs et al., 2001). One study by G. Wess et al. (2010) investigates ability of a 5-minute electrocardiography for predicting arrhythmias in Doberman Pinschers with cardiomyopathy in comparison with a 24-hour ambulatory ECG. However, no large study exists evaluating the use of a physical examination, routine ECG and comparing the results to the Holter recordings for assessing heart rate variability in Doberman Pinschers (Goodwin, Cattiny, 1995). Heart rate (HR) is modulated by the combined effects of the sympathetic and parasympathetic nervous systems. Therefore, measurement of changes in HR over time (heart rate variability or HRV) provides information about autonomic functioning. HRV has been used to identify high-risk people, understand the autonomic components of different disorders and to evaluate the effect of different interventions, etc. (Stein, Pu, 2012).
The aim of this study was to evaluate and compare main heart rate parameters in clinically healthy Doberman Pinschers, obtained during physical examination, routine ECG and 24-hour Holter monitoring.

MATERIALS AND METHODS

11 clinically healthy, client-owned Doberman pincher dogs (7 female, 4 male, mean age 4 years, range 1 – 8 years) were used in this study. Examination of each dog included physical, routine ECG and a 24-hour ambulatory ECG (Holter) examination.

Physical examination. Mean heart rate and presence or absence of arrhythmias was detected by cardiac auscultation and pulse palpation on *a. femoralis.*

Routine ECG. Dogs were positioned in right lateral recumbency. ECG was performed according to standard technique with 4 limb electrodes placed proximal to the elbows and over the stifles (red for right arm, black for right leg, yellow for left arm, green for left leg). Electrical activity was recorded for 5 minutes, with a 12-channel ECG machine STL-08 SD. 6 leads (I, II, III, aVR, aVL, aVF) were obtained. For current study only data registered with II lead were used.

Holter Examination. A 24-hour, 2 channel ECG recording system Televet 100 (with 6 vectors, I, II, III, aVR, aVL, aVF) was used. Holter ECG was performed immediately after performing the in-hospital ECG. Each dog was released from the hospital to allow for monitoring of the dog's electrical activity in its normal environment. Because of scheduling constraints, all recordings could not be started at the same time of day.

The Holter recording system weighed about 0.5 kg. Four electrodes provided 2 recording channels and a ground. The recorder (Televet 100) was directly attached to each dog as described below. Hair at the electrode sites was clipped and skin was cleansed with alcohol and dried afterwards with dry swab. Adhesive electrodes were attached to the prepared area: yellow – at the level of base of heart, third left intercostal space, green – sixth left intercostal space in the costochondral junction location, red over the apex beat on the right side, black on the sternum. The lead wires were then snapped on to the electrodes. During electrode attachment, lead wires were directed dorsally. Adhesive elastic bandage was wrapped around the chest to secure electrodes and to protect lead wires and recorder. Holter recordings were reviewed and analyzed by the author. Data evaluated included hourly and 24-hour summaries of average heart rate, minimum and maximum sinus R-R intervals, heart rhythm, total count of ectopic complexes.

Results were analyzed statistically by Microsoft Excel 2010 and IBM SPSS 20. Mean values and standard deviation were calculated. Paired samples T-test was used for assessment of mean values.

RESULTS AND DISCUSION

A total of 33 examinations, including physical examination, routine ECG and Holter examination, were performed on 11 clinically healthy Doberman Pinschers.

All Doberman Pinschers used in this study had sinus rhythm and respiratory arrhythmia during rest periods in the ECG recordings obtained. There was a significant difference between average heart rates obtained with three different methods. Mean heart rates obtained with routine ECG, were significantly higher ($p<0.001$) than those recorded using Holter monitoring. Results of the physical examination were not statistically significantly different from Holter monitoring results (Fig 1.). Mean heart rates obtained with Holter monitoring are lower due to the fact that Holter monitoring reflects average results obtained from longest period of time, including periods of sleep, awake and exercise. Reason for higher values of mean heart rate obtained during routine ECG is that most likely ECG procedure causes more stress in dogs rather than physical examination, and stress in known to be one of the main reasons for elevation of heart rate.

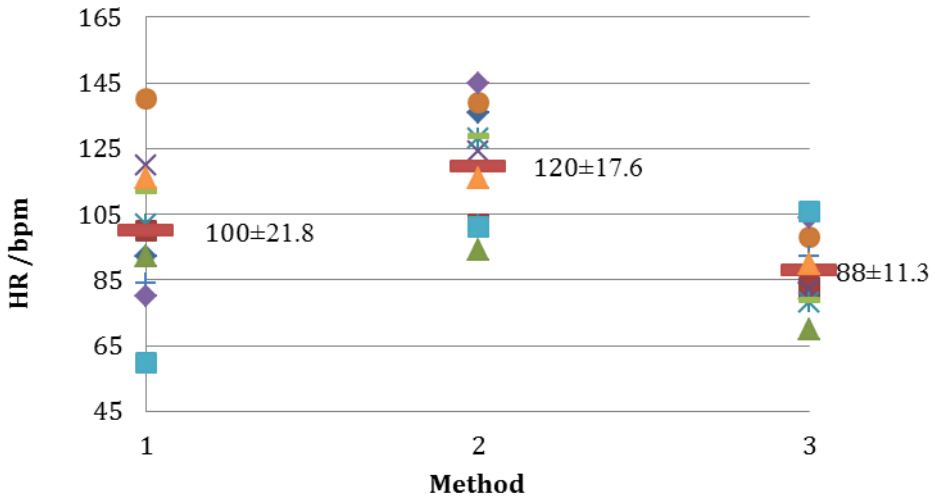

Figure 1. **Comparison of the heart rate (mean±SD) (HR) obtained during physical examination (1), routine ECG (2) and Holter monitoring (3)**

Average heart rates of dogs vary every hour (Fig.2). Noticeably lower heart rate in all dogs can be observed in the time period between 23:00 and 05:00 in the morning. During this period mean heart rate did not exceed 120 bpm in any dog. There are no remarkable periods of high heart rate. Heart rate variability over 24h period using Holter monitoring is shown in Fig 2. Several studies in humans show trend of minimum heart rates from 2 am to 5 am when the subjects were asleep, while the maximum heart rates trends were found during 1pm to 4pm (awake period). In humans, both the minimum and the maximum heart rates during the wake period are significantly higher than the heart rate values during sleep. These observations in humans reflect the increased parasympathetic and decreased sympathetic tone during sleep (Alan et al. 1982, Bleifer et al. 1980, Brodsky et al. 1977, Sabotka et al. 1981). In dogs, however, it is difficult to define real time and duration of sleep, as it is based only on owners' evidence.

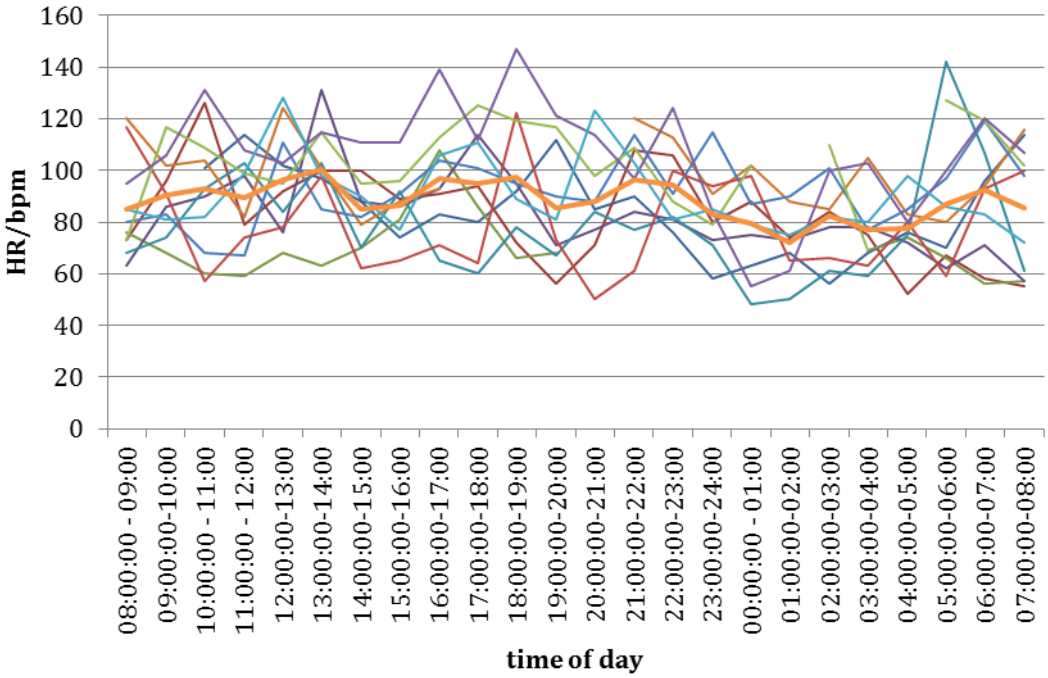

Figure 2. **Heart rate variability of 11 dogs over 24-hour period using Holter monitoring. Orange line indicates mean heart rate of all dogs**

Minimum RR intervals ranged from 0.22sec to 0.31sec with an average of 0.26sec. Maximum sinus RR intervals ranged from 0.93sec to 2.5sec with an average of 1.53 sec. Fig 3. Illustrate minimum and maximum sinus RR intervals (sec) of each dog in a 24-hour period. It was observed that minimum sinus RR interval was similar in all dogs, but there was a range in amplitude between maximum sinus RR intervals of all dogs.

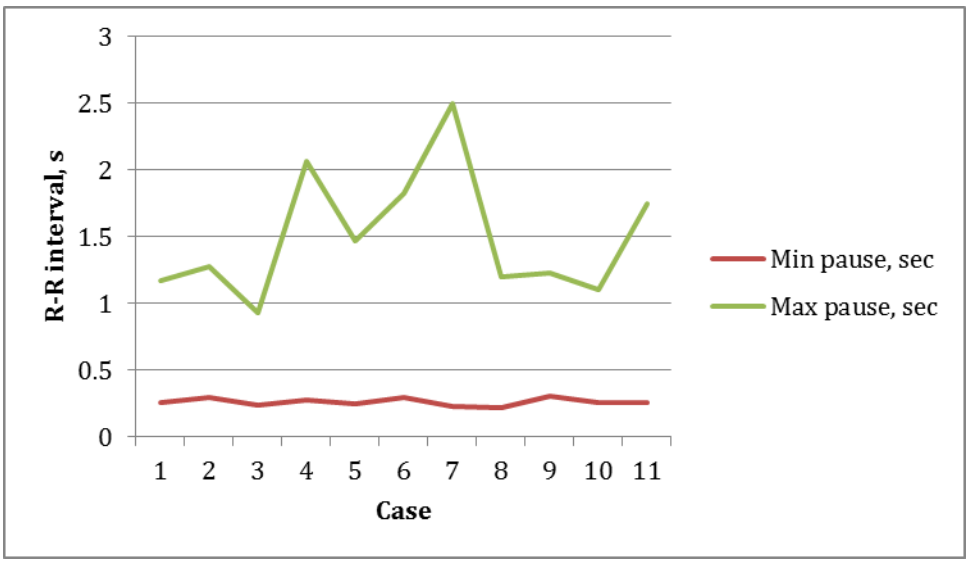

Figure 3. **Minimum and maximum sinus RR intervals (sec) of each dog in a 24-hour period**

Interestingly no ventricular premature complexes (VPCs) were found during routine ECG examination, while all dogs had at least one VPC over 24-hour period (Table 1.) The amount of VPCs ranged from 1 to 35, (mean 11). Fewer than 50 VPCs/24 hours are considered

normal in Doberman Pinchers. Study by G. Wess et al. (2010) showed a low sensitivity but high specificity of a 5-minute ECG to predict 4100 VPCs/24 hours, if at least 1 VPC is detected within 5 minutes. The absence of VPCs in the 5-minute ECG should not lead to the assumption that the dog is healthy, because false negative cases were found in 35.8% of the examinations. A 5-minute ECG cannot replace a 24-hour ECG examination for the purpose of detecting the occult phase of DCM in Doberman Pinschers and the absence of VPCs on a 5-minute ECG does not preclude the occurrence of VPCs during the rest of the day (Wess et al. 2010). Current study shows that routine ECG corresponds to a small fraction of the dog's rhythm over a 24-hour period, and identification of abnormalities may be entirely incidental.

Table 1

Total number of ventricular premature complexes (VPCs) during routine ECG and 24-hour Holter examination

Case Nr.	1	2	3	4	5	6	7	8	9	10	11
Number of VPCs during routine ECG	0	0	0	0	0	0	0	0	0	0	0
Number of VPCs during 24–hour Holter examination	6	8	1	15	7	18	2	4	19	35	6

CONCLUSIONS

1. Physical examination method for evaluation of mean heart rate in dogs is more objective as compared to routine ECG.
2. Mean heart rates obtained with routine ECG, were significantly higher ($p<0.001$) than heart rate obtained during physical examination and recorded using Holter monitoring. Presumably routine ECG procedure causes more stress in dogs since they are positioned in a forced lateral recumbency.
3. Noticeably lower heart rate in all dogs can be observed in the time period between 23:00 and 05:00 in the morning. During this period mean heart rate did not exceed 120 bpm in any dog.
4. Respiratory sinus arrhythmia was observed in all dogs.
5. There is a wide range in amplitude between maximum sinus RR intervals of all dogs and consequently heart rate is very variable.
6. Routine ECG is an inapplicable method for detecting small number of ventricular premature complexes (VPCs).
7. Data obtained during this study illustrate normal cardio rhythmic functions in healthy adult Doberman Pinchers, and may be used as a comparative measure in analyzing the rhythm disturbances in patients with cardiac or non-cardiac problems.

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