Clinical signs caused by the use of electric training collars on dogs in everyday life situations[☆]

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Abstract

The use of electric shock collars for training dogs is the subject of considerable controversy. Supporters claim that they are a reliable means of eliminating self-rewarding behaviour and that they can be used over greater distances and with less risk of stress and injury than mechanical devices, such as choke chains. Opponents cite the risk of incorrect or abusive use and temptation to use electric training collars without thought or time given to alternative training methods, regardless of the fact that their use may be associated with pain and fear. The aim of this study was to investigate whether any stress is caused by the use of electric shock collars or not and in this way to contribute to their evaluation with respect to animal welfare.

Fourteen laboratory-bred Beagles were used to ensure standardised breeding, raising and training. Heart rate and saliva cortisol were used as stress parameters. The research project lasted for 7 months, during which each dog was trained for 1.5 h per day. To exclude circadian deviations of salivary cortisol values, each individual was allocated a rigid timeslot. Training as well as the experiments themselves were conducted in a secluded storage building to exclude the influence of external stressors.

Three experimental groups were used. Group A (Aversion) received the electric shock when the dogs touched the prey—a rabbit dummy fixed to a motion device. Group H (Here) received the electric shock when they did not obey a previously trained recall command during hunting. Animals of group R (Random) received the electric shock arbitrarily, i.e. the shock was administered unpredictably and out of context.

The main experiment lasted for 17 days. All animals were allowed to hunt unimpeded for the first 5 days. For the next 5 days the dogs were stopped from hunting by a leash. Every day, the stress parameters were determined. These values were compared with the values that were obtained during the use of the electric training collars. The collars were used over a period of 7 days as described previously. After 4 weeks the dogs were brought back into the research area without receiving an electric pulse.

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Group A did not show a significant rise in salivary cortisol levels, while group R and group H did show a significant rise. When the animals were reintroduced to the research area after 4 weeks, the results remained the same.

This led to the conclusion that animals, which were able to clearly associate the electric stimulus with their action, i.e. touching the prey, and consequently were able to predict and control the stressor, did not show considerable or persistent stress indicators.

1. Introduction

Dogs frequently exhibit undesirable behaviour, which their owners would like to eliminate. Methods used to achieve this include a change of voice, training the dog to stop the behaviour to a specific signal, frightening the dog with loud noises, and electronic training (shock) collars. In Germany, these collars are sometimes applied in police dog training as well as in training hunting dogs and dogs for competitive sport. Electronic collars are also used in the training of pet dogs to stop unwanted hunting behaviour for example. However, the use of these collars in dog training is a matter of considerable controversy.

Supporters of the collars see them as an effective means of reliably eliminating self-rewarding behaviour, such as unwanted hunting behaviour. According to Christiansen et al. (2001), the use of such collars on dogs is an efficient way of preventing dogs from chasing or attacking grazing sheep. In addition to this, supporters claim that the use of these devices means less strain for dogs than the use of any other, mechanically operated means of education such as, for example, choke chains. Klein (2003) states that some authors stress the advantage of these instruments, claiming that their application does not cause any physical injury, whereas mechanically operated equipment and inappropriate training techniques can result in small injuries such as bruises or even severe damage such as a ruptured spleen. Another advantage of devices like electronic collars according to their supporters is the ability to use them over greater distances. Weick (1976) even goes as far as to call their invention the fulfilment of a dream in dog training: contiguousness of unwanted behaviour and punishment.

Adversaries of electronic collars see a high risk of incorrect and abusive use since it is tempting to apply these easy-to-use devices without spending much thought on alternative training methods. They believe that, particularly in situations where they are applied to achieve quick success in dog sport, their use is at the dog's expense and should be prohibited. Schilder and van der Borg (2003) suggest banning these instruments from dog sport completely. As an alternative they suggest that trainers and handlers should study learning theory more thoroughly and reconsider the structure of their training. Furthermore, their findings demonstrate that, apart from causing discomfort for the animal being trained, the use of electronic collars is also associated with pain and fear, when an electric shock is delivered. The parameter these two authors used for their evaluation was the dogs' body language. In 1998, Beerda et al. detected a correlation between a very low body posture and salivary cortisol level. Salivary cortisol levels and heart rate can be measured simultaneously to improve the interpretation of behavioural data with regard to stress since together, they provide an indication of the activity of two physiological systems that respond to acute stress in dogs, the sympathetic nervous system and the hypothalamic pituitary adrenal (HPA) axis (Stichnoth, 2002).

The aim of the current study was to investigate the intensity of stress signs arising from the use of electronic training collars. The level of stress was determined by measuring and analysing the levels of salivary cortisol and heart rate.

In this study situations that often occur in dog training were reconstructed under experimental conditions:

1. The elimination of hunting behaviour.
2. Punishment of a dog disobeying a verbal recall signal from a prey.
3. The application of electric shocks in a form that prevents the dog from associating the stimulus either with its behaviour or a verbal signal, thus simulating inappropriate use by the owner.

2. Materials and methods

2.1. Animals

In order to minimise variability among the dogs regarding their past experience, all dogs in the study were chosen according to their hunting behaviour from Beagles from the laboratory animal breeding stock of 25 animals from the ''Tierfarm Kirchheimer Muehle'' of the University of Heidelberg. These dogs lived in groups of five or six, separated according to gender. The kennels each measured 70 m^2 and included a freely available heated room. The dogs were fed commercial dry food twice daily, in the morning and in the evening, and had water at their free disposal.

Five female and nine male Beagles, aged between 1.5 and 2 years took part in the research project. Before starting any experiment, all dogs were examined by a veterinarian and were found to be healthy. The veterinary examination included a general clinical examination as well as a screen for salivary cortisol (see below). Prior to the start of the study, the dogs only had contact with humans during the daily feeding and grooming routines. They were not accustomed to being separated from their kennel mates.

2.2. Test area

All tests were carried out in a room on the second floor of a building located on the ''Tierfarm Kirchheimer Muehle'', accessible by some stairs. The building was situated at a distance of about 120 m from the kennels. The room was 11.10 m long and 5.20 m wide with a height of 2.50 m. It had one door, two radiators, two windows, two shelves and a sink.

For the study, the dogs were removed one by one from their kennels and put into separate transport kennels by the laboratory technician and researcher. The transport kennels were brought to the test building by tractor and unloaded in front of it. To minimise stress on the dogs concerned, dogs that lived together were taken to the test area together.

The dogs were taken individually from their transport kennel, put on a leash, and led upstairs into the test area. Immediately after entering the room, the dog was equipped with a belt for measuring the heart rate, and either an electronic training collar or a dummy collar.

2.3. Equipment and sampling

2.3.1. Electronic training collar

The electronic training collar used in this research was a ''Teletakt micro 3000'', produced by Schecker GmbH & Co. The complete device consisted of a transmitter, a collar with a receiver, and an identical dummy collar with a fake receiver. It had a maximum range of 500–600 m. The transmitter had a button to trigger the electric current, and could be run at levels ''0'' (device switched off), and ''1'' (weakest impulse) up to ''5'' (strongest impulse). The collar with the receiver had two electrodes on its inside, which had to be

in close contact with the dog's skin. According to the manufacturer of the device, the electric impulse had a duration of less than 1 ms. Before using the collar on a dog the current, voltage, and duration of the impulse were measured. Since these values are dependent on the skin resistance, the devices were tested using resistances between 500 Ω and 2.2 kΩ, to simulate skin resistance. When operating the device at level 5 the results were as follows:

Resistance (Ω)	Peak voltage (V)	Peak current (A)
500	700	1.25
2200	1760	0.82

In this investigation the device was run at level "5" in all of the experiments. This level was chosen in order to investigate the dogs' reactions under the highest electric pulse and as such the worst condition possible.

2.3.2. Heart rate measurement

Measurement of heart rate was carried out with a Polar® Horse Trainer Transmitter and a Polar® Vantage NVTM heart rate measuring instrument for horses. Preliminary studies carried out at the Department for Animal Welfare and Behaviour had proved both devices to be a reliable means for the heart rate measurement. The data was read into the Polar Precision Performance™ programme (Polar® heart rate monitors, Baumann & Haldi SA) via a serial interface. After activation, the receiver averaged the heart rate and recorded a value in beats per minute every 5 s. Since the receiver included a stopwatch-function and a second stopwatch was run simultaneously, the events occurring in the dog's environment could be correlated with its heart rate. The dogs had to wear the transmitter from the first day of the adaptation phase until the end of the post-test.

2.3.3. Salivary cortisol measurement

A small amount of citric acid was put into the dog's mouths to stimulate the secretion of saliva. Afterwards, the saliva sample was taken from the dog's cheek pouches with a cotton bud made by Salivette® Systems (Sarstedt AG & Co). Directly following this, the Salivettes were centrifuged at a speed of 4000 rpm and cooled down to a temperature of −20 °C. The measurement of the salivary cortisol values was carried out by the laboratory of the University of Heidelberg. The laboratory staff carrying out the salivary cortisol measurement were blinded as to which of the three groups of dogs a sample belonged. For the measurement, a radio-immuno-assay with Tritium-marked cortisol and autoantibodies was used. The Intraassay variance was 5%, the Interassay variance 10%, and the lowest detection limit was at 0.1 ng/ml. The repeatability rate was >95%.

2.4. Procedure

The research project lasted from September 2000 to March 2001. The experiment was carried out in two phases—adaptation: familiarisation with the environment, main experiment: hunting behaviour

For the experiment, the dogs were divided into three groups:

Group A ("Aversion")	Consisted of three male and two female dogs that received an electric pulse at precisely the moment they touched the prey, thus forming an association between touching the prey and the electric stimulus
Group H ("Here")	Consisted of two male and two female dogs that received an electric pulse when they did not obey a recall during hunting, having been previously trained to recall during the adaptation phase
Group R ("Random")	Consisted of four male dogs and one female dog that received an electric pulse arbitrarily, meaning that the stimulus was administered unpredictably and out of context, either prior to orientation towards the prey, or while hunting, or after having finished the hunting process when there was no prey in the room anymore. The decision at which moment the electric pulse had to be administered was made by drawing lots

2.4.1. Adaptation phase

All of the dogs initially experienced an adaptation phase that lasted 3 months. During this period, the dogs were accustomed to the daily routine, the room in which the tests took place, the persons carrying out the tests as well as the absence of their kennel mates. Every one of the dogs was trained to hunt a rabbit dummy. Dogs belonging to group H were additionally trained with the verbal signal "Here" as a recall signal. The adaptation phase was concluded when every single dog was able to move around inside the testing room without displaying signs of fear and stress, and showed clear forward movement on the leash on its way to the room. Each dog was worked once a day for 1.5 h within a rigid timeslot.

2.4.2. Main experiment

2.4.2.1. Base levels. In order to determine the baseline levels for salivary cortisol and heart rate, every dog was led into the room on its own. It spent 50 min inside the room without anyone paying attention to it. After these 50 min, continuous heart rate measurement was started and saliva samples were taken every 5 min.

2.4.2.2. Preliminary test. The preliminary test was subdivided into two periods of 5 days each. During the first period called "Simple Hunting", each animal was allowed to hunt unimpeded. The hunting sequence lasted for 1–2 min, and the dog was allowed to take hold of the prey and carry it off. Ten minutes after the end of the hunting sequence, five saliva samples were taken at intervals of 5 min. The heart rate was measured throughout the whole period. During the second period called "Hunting Impeded", the dogs were prevented from hunting by using a leash. The prey was presented to the dogs, but hunting was made impossible by using a 1.50 m leash. The "Hunting Impeded" period was terminated after 2 min by removing the prey. Saliva sampling and heart rate measurement were carried out in exactly the same way and timing.

The preliminary test made sure that every dog was also examined in a situation in which it had not been given an electric pulse, in this way, each dog could be used as its own control.

2.4.2.3. Main test. During the main test, electric pulses were administered to the dogs in accordance with the group to which they belonged. Each dog was allowed a maximum of one electric pulse per day. The main test was terminated for each individual dog as soon as it either did not show any interest in the prey on three successive days, or obeyed the recall signal, or displayed distinct signs of stress in the experimental environment, or after the third application of an electric pulse. The heart rate was continually measured the whole time. The five saliva samples were taken at intervals of 5 min; the first was taken 10 min after the application of the electric pulse.

2.4.2.4. Post-test. For 4 weeks after the main test, the dogs did not have any contact with either the experimental environment or the person conducting the experiments. At the end of the 4 weeks, they were again taken into the experimental environment, the five saliva samples were taken, and the heart rate was measured.

The study was approved by the animal welfare officer of the Veterinary School of Hanover and by the Governmental authorities according to the German Animal Welfare Act.

2.5. Data processing

2.5.1. Cortisol level

The following key values were derived from the results of the cortisol measurement:

1. The cortisol values gained directly from the saliva samples were called "Absolute Cortisol Values".
2. In order to minimise influence arising from each dog's individual cortisol level, all cortisol values were divided by the average of the cortisol values measured on the 5 days of the period of "Simple Hunting". The values gained in this way were called "Relative Cortisol Values". The values of the "Simple Hunting" periods were deliberately chosen as reference values because they were lower than the baseline levels.

2.5.2. Heart rate

The data collected during the heart rate measurement period were plotted both for the "Simple Hunting" and "Hunting Impeded" periods of the preliminary test as well as for the main test. As each curve contained some fluctuation, the original curves were divided into 3 min segments. The average was calculated for each of these segments, and this produced a new, smooth curve. This curve was then used to calculate the time necessary for the heart rate to return to its normal value.

The following key values were derived from the results of the heart rate measurements:

1. The maximum value of the heart rate at the point the stressor (electric pulse) occurred was determined. For each curve, there was one maximum value called "Max".
2. In the period that began 15 min after the stressor had occurred and ended 30 min after the stressor had occurred, the heart rate was measured. Of the values determined an average value was formed. For each curve, there was one value called "Mw15".
3. The ratio between "Max" and "Mw15" was formed in order to balance possible individual heart rate levels. For each curve, there was one "Max/Mw15".
4. The period of time between "Max" and "Mw15" was determined. For each curve, there was one "Max–Mw15".

During the measurement of baseline levels and during the post-test, possible stressors (electric current or prey) were not presented. Here, the average of the entire curve was calculated.

2.5.2.1. Experiment with electric pulses.
The application of the electric current had a number of possible behavioural consequences:

1. The dog stopped hunting after the first application and could not be stimulated to hunt in the following trials.
2. The dog stopped hunting after the second application and could not be stimulated to hunt in the following trials.
3. The dog stopped hunting after the third application and could not be stimulated to hunt in the following trials.

In order to be able to compare the collected data, datasets were compiled according to the number of days that electric pulses were administered and those without. This resulted in the following five datasets:

"r1–r3, n1"	Three days of application of the electric pulse, and the first day without the stimulus. This set included data from two dogs of group R and from one dog of group A
"r1–r2, n1–n3"	Day 1 and 2 with application of electric pulse, and day 1, 2 and 3 without the stimulus. This set included data from three dogs of each group
"r1–r2, n1"	Day 1 and 2 with application of electric pulse and day 1 without. This dataset included data from four dogs of group A, three dogs of group H, and five dogs from group R.
"r1, n1–n3"	Day 1 with application of the electric pulse, and day 1, 2 and 3 without. This dataset included data from four dogs from group A, four dogs from group H, and three dogs from group R
"r1, n1"	Day 1 with application of the electric pulse, and day 1 without. Data of all of the 14 dogs were compiled

2.6. Statistical analysis

Statistical analysis was carried out using the statistics programme SIGMASTAT® as well as EXCEL 97. A significance level of $p < 0.05$ was used for all tests. When comparing results of two dogs, a t-test for unpaired comparison was carried out. In cases where the data were not normally distributed, the Mann–Whitney U-test was applied. When comparing results of more than two dogs, a one-way ANOVA was conducted. In cases where the data were not normally distributed, the Kruskal–Wallis H-test was performed.

When comparing a single dog's results collected on two different days, a paired *t*-test was carried out. In cases where the data were not normally distributed, the Wilcoxon–Rank test was used.

When comparing a single dog's results gathered from more than 2 days, a one-way or two-way ANOVA for repeated measurements was conducted. In cases where the data were not normally distributed, a one-way ANOVA for repeated measures (Friedman) was performed.

In cases where significant differences were detected, the data were compared using Tukey-test or Dunn's test.

3. Results

3.1. Establishing reference values

In order to determine whether the dogs' salivary cortisol baseline levels could be used as reference values for this research, they were compared to the cortisol values gathered from both the periods "Simple Hunting" and "Hunting Impeded" of the preliminary test. This showed that the salivary cortisol baseline levels were higher than the values gained during the period of "Simple Hunting". Therefore, the baseline levels were not suitable as reference values. Instead, the average of the salivary cortisol values collected during the period of "Simple Hunting" was used for every dog. As described in "Section 2 and Methods", this average was needed for calculating the "Relative Cortisol Values".

Concerning the heart rate, the baseline levels of the heart rate were compared to the averages of the "Mw15" values gained during the preliminary test. No significant differences were detected ($p = 0.57$–1.0). Therefore, "Mw15" values were chosen as reference values.

3.2. Preliminary tests without application of electric pulses

 (i) Comparison of "Simple Hunting" and "Hunting Impeded" in general "Absolute Cortisol Values" as well as "Relative Cortisol Values" gained from the period of "Hunting Impeded" were found to be significantly higher than those during "Simple Hunting" ($p \leq 0.001$ and $p \leq 0.001$).
(ii) Comparison of "Simple Hunting" and "Hunting Impeded" concerning groups A, H and R. When comparing the salivary cortisol results of groups A, H and R collected during the preliminary tests, it was found that during "Simple Hunting", the "Absolute Cortisol Values" of group H were significantly less than those of both group A and R ($p < 0.05$). During "Hunting Impeded", the "Relative Cortisol Values" of group R were significantly less than those of both group A and H ($p < 0.05$). No significant differences were discovered in heart rates.

3.2.1. Main tests with application of electric pulses
3.2.1.1. *Comparison of salivary cortisol values.* For the three groups A, H, and R the "Absolute Cortisol Values" as well as "Relative Cortisol Values" were analysed. The mean value of all dogs per group per day was taken. Subsequently, those values for day 1, 2 and 3 with electric pulses and day 1 without were compared and checked for differences.

3.2.1.2. *Dataset "r1–r3, n1".* Comparing the groups of dogs, the following was found: considering the 4 days "r1", "r2", "r3", and "n1" altogether, "Absolute Cortisol Values" and "Relative Cortisol Values" of group R were significantly higher than those of group A ($p < 0.05$ and $p < 0.05$). Considering only day "r1", no significant difference between the values for group

A and those for group R was detected (difference of averages [MW-Diff] 0.39 ng/ml). Considering the other 3 days, "r2", "r3", and "n1", the "Absolute Cortisol Values" for group R were significantly higher than those for group A (MW-Diff 2.57, 2.94, and 1.87 ng/ml).

Comparing the different days an electric stimulus was applied, in group A no significant difference was detected. However, the highest value was measured on day "r1". In group R, the values recorded on day "r3" were significantly higher than those recorded on day "r1" (MW-Diff 2.70 ng/ml) and those recorded on day "n1" (MW-Diff 1.19 ng/ml). Also, the values recorded on day "r1" were significantly lower than those recorded on day "r2" (MW-Diff 2.34 ng/ml) and those recorded on day "n1" (MW-Diff 1.50 ng/ml).

Altogether, the results described above show a continuous increase in "Absolute Cortisol Values" for group R from day "r1" until day "r3". On day "n1", the values show a decrease, however, the value is still higher compared to the day that the first electric pulse was administered.

3.2.1.3. Datasets "r1–r2, n1–n3", "r1, n1–n3" and "r1–r2, n1". Concerning both "Absolute Cortisol Values" and "Relative Cortisol Values", the results collected from group "R" were significantly higher than those gained from both group A and group H ($p < 0.05$). Furthermore, the "Relative Cortisol Values" gained from group H were significantly higher than those gained from group A ($p < 0.05$).

3.2.1.4. Dataset "r1, n1". Concerning both "Absolute Cortisol Values" and "Relative Cortisol Values", the results taken from group R were significantly higher than those taken from both groups A and H, respectively.

3.2.2. Comparison of heart rate values

For the comparison of the heart rate measurements, the key figures "Max", "Mw15", "Max/Mw15" and "Max–Mw15" were used.

3.2.2.1. Datasets "r1–r2, n1", "r1, n1" and "r1–r3, n1". For these datasets no significant differences in heart rate were found.

3.2.2.2. Dataset "r1–r2, n1–n3". Concerning the key values "Mw15", "Max/Mw15", and "Max–Mw15", no significant differences were found between the groups of dogs or between the different days of the experiment. However, concerning "Max", significant differences existed.

3.2.2.3. Dataset "r1, n1–n3". Significant differences were found between the values of "Mw15" in respect of the application of the electric pulse ($p = 0.02$), as well as in respect of the values of "Max/Mw15" when comparing group A with group H and R ($p = 0.027$).

3.3. Post-tests

3.3.1. Comparison of saliva cortisol values

In "Absolute Cortisol Values" and "Relative Cortisol Values", significant differences ($p < 0.001$) between the groups of dogs were detected. The cortisol values gained from group R were the highest ones, the values gained from group A the lowest ones recorded.

3.3.2. Comparison of heart rate values

Concerning the heart rates, no significant differences between the groups of dogs were found.

3.3.3. Comparison between, preliminary test, main test, and post-test

For statistical reasons, only day ''r1'' and day ''n1'' were taken into account.

Within group A, significant differences were found for ''Absolute Cortisol Values''. The values collected on the fifth day of the period ''Hunting Impeded'' were significantly higher than the values recorded during the post-test. No significant differences were found for ''Relative Cortisol Values''.

Within group H, both ''Absolute Cortisol Values'' as well as ''Relative Cortisol Values'' gained during the post-test were significantly higher than the values recorded on the second and the third day of the period of ''Simple Hunting''. The salivary cortisol levels measured during the preliminary test were not reached again during the post-tests.

Concerning group R, the ''Absolute Cortisol Values'' and the ''Relative Cortisol Values'' measured during the post-test were higher than those gathered on all of the days of the preliminary test as well as the first day of application of the electric pulse.

4. Discussion

Data recording in the preliminary test was carried out for the following reasons:

Simple Hunting	To evaluate whether the parameters simply change due to the current chase sequence
Hunting Impeded	To investigate whether stress in a dog on the lead can be compared with stress caused by the use of an electronic training collar

The complete experimental design of preliminary test, main test, and post-test was set up in an unchanging, isolated room. Thus, exclusion of uncontrollable stressors from the outside could be guaranteed and corruption of the rest results prevented.

The 14 dogs used in this experiment were exclusively laboratory animals obtained from the same laboratory animal breeder. Before the experiment the dogs did not have any intensive contact to humans. Therefore it might be assumed that the 14 Beagles were less tolerant to stress than dogs living in a private household from a very young age on. However, the advantage of laboratory animal husbandry is that standardisation of breeding, upbringing, and husbandry is achieved. Therefore, varying behavioural performances and a varying reactivity amongst the dogs cannot be readily attributed to differences in their previous experience. The experimental groups can thus be more reasonably compared with one another. Furthermore the animals' environment can be controlled more easily, which made the control of potential stressors on the day of the experiment easier than it would have been in a private household and as a result, uncontrolled influences on the experimental data are reduced to a minimum.

Experiments and data recordings were carried out over time periods of up to 1.5 h for each dog. Distortion of the experimental results due to slight shifts in saliva sampling is not to be expected. This is supported by the findings of Kemppainen and Sartin (1984) and Thun et al. (1990) who found no circadian rhythm to ACTH-release in the dog.

Stress leads to activation of the hypothalamic pituitary adrenal axis (HPA-axis) resulting in a release of corticosteroids (Henry and Stephans, 1977). In this study we used salivary samples to determine the level of this steroid hormone so as to be able to repeat tests over a relatively short period of time with the lowest amount of stress as possible. This method simplifies experimental

processes considerably and makes it possible to extend investigations over a longer time period (Greenwood and Shutt, 1992; Zanella, 1992; Parrott et al., 1989; Walker, 1989; Fell et al., 1985).

The technique is valid because there is a high to very high correlation between overall cortisol and salivary cortisol in dogs (Vincent and Michell, 1992; Beerda, 1997). According to Vincent and Michell (1992), the cortisol concentration in canine saliva is about 4–10% of the plasma cortisol. Beerda (1997) found saliva cortisol concentration to have a value between 7.2% and 11% of plasma cortisol concentration.

The median of baseline cortisol level found by Vincent and Michell (1992) and Beerda (1997) is higher than that recorded in this study. However, the median baseline values found in this study was between 27.1% and 27.7% of their findings. The values measured in this study before an electric pulse was administered correspond to only a fifth and a third respectively of the values found in the literature. As the rate of cortisol recovery in the test is as high as 95%, this cannot be attributed to the inter- and intra-assay variance of 5% and 10 %, respectively. One possibility is that there is a loss of cortisol due the additional step in the extraction procedure, using citric acid. Stimulation of salivation with citric acid does not alter the experimental results. Beerda (1997), for example, used citric acid as a stimulant to increase salivation. So long as the current study does not attempt to draw any conclusion from direct comparison of values with those stated in the literature elsewhere, this is not a problem as the values of this study are consistent. Thun and Schwartz-Porsche (1994) draw attention to the fact that released cortisol can mask a circadian rhythm. Therefore it seems unlikely that testing the dogs within a time variant of up to 1.5 h affected the results. Another possible explanation of the difference lies in the proposition that the laboratory animals were more relaxed because they were adapted to the experimental environment. However, the data for the electronic collar phase of the study is not consistent with this idea.

The importance of collecting at least one cardiovascular parameter in addition to neuroendocrine parameters has been indicated in the literature (Vincent et al., 1993). This study used the suggested procedure of measurement of heart rate. It has been suggested that heart rate frequency reaches higher values when tested animals are given the chance to evade a stimulus (Anderson and Brady, 1971, 1972, 1973, 1976; Anderson and Tosheff, 1973). However, in previous studies the animals' mobility has been restricted. This was not the case in this study. Therefore, stress-induced and motion-induced changes of heart rate frequency could overlap.

Kirschbaum and Hellhammer (1989), Laudat et al. (1988) and Riad-Fahmy et al. (1983) state that there is a high individuality in baseline cortisol values as a result of psychological stimulation as well as after the application of dexamethasone even under standard experimental conditions. To exclude falsification of future measurement due to the individual cortisol concentrations of the randomly assigned groups their cortisol levels were tested in the preliminary test, where group R shows lower cortisol values than the two other groups. In the Hunting Impeded period, groups H and A show significantly higher relative cortisol values than group R. This suggests that the results obtained from the experiment with an electronic collar and those from the post-test are not influenced by the composition of the group.

The interpretation of the heart frequencies is more complicated since stress induced reactions are likely to be overlapped by those triggered by physical activity. Yet it is striking that on the days of stimulus application, an increase in the maxima of heart rate is reached in group ''R''. In group A and H this is the reverse. Anderson and Brady (1971, 1972, 1973, 1976) describe a decrease in heart frequency if animals are given the possibility to evade the stressors.

Since the animals of group R unlike those of group A and H had no chance to associate their behaviour or a warning signal like the ''recall'' with the punishing stimulus, this could explain the increase in heart rate on the days of stimulus application.

The results of the cortisol determination show that there is least increase in the absolute and relative values (between 22.45% and 31.31%) in group A. This increase is even lower than that which occurred during the "Hunting Impeded" period. Group H follows with an increase of up to 113.89% in terms of absolute cortisol levels and up to 160% concerning the relative cortisol values. The highest increase is seen in group R with up to 336.36% in the absolute cortisol values and up to 327.78% in the relative cortisol values. The values of group R are significantly higher in each set of data than those of group H and A. In the data set r1, n1, the relative cortisol values are significantly higher in group H than those of group A. Beerda (1997) reports a cortisol increase due to unpredictable stressors, such as sudden noise, of about 374%, while Palazzolo and Quadri (1987) reported an increase of more than 250% if the animals were exposed to a temperature of −5 °C for an hour. Weiss (1972) asserts that the predictability of the stressor is of crucial importance. Dess et al. (1983) postulate that the ability to control the stressor is even more important than its predictability. The development of plasma cortisol values can therefore be explained thus. The dogs of group A were able to associate the prey with the application of the stimulus. Thus the animals were able to predict and to control the stimulus. This explains the lowest increase of only up to 31.3% in relative cortisol values. In group H the audio-signal "Here" had been trained but not in conjunction with prey being present. As a result of this lack of specific training, application of the stimulus could be predicted by the dogs, but they were not able to control their initial reaction, i.e. chasing the prey. This might be the reason for the distinct increase of cortisol values up to 160% in the relative cortisol values. However, the increase was not as high as that of 327.78% in group R. The animals of group R were neither able to control nor predict the stimulus due to its random application. The increase is similar to the values found in literature concerning an unpredictable stressor. This corresponds with the result of the post-test and Polsky's (1994) statement that a lack of timing and/or electric shock that lasts too long causes a fear of the environment/of people in dogs.

The results are consistent with Feddersen-Petersen and Teutsch (1999) as well as Grauvogl (1991) who found that poor timing i.e. the impossibility to associate electric shock and stimulus leads to insecurity and extreme states of anxiety.

5. Conclusion

The results of this study suggest that poor timing in the application of high level electric pulses, such as those used in this study, means there is a high risk that dogs will show severe and persistent stress symptoms.

We recommend that the use of these devices should be restricted with proof of theoretical and practical qualification required and then the use of these devices should only be allowed in strictly specified situations.

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