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The effect of a pressure wrap (ThunderShirt®) on heart rate and behavior in canines diagnosed with anxiety disorder

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Research

The effect of a pressure wrap (ThunderShirt®) on heart rate and behavior in canines diagnosed with anxiety disorder

A B S T R A C T

The effect of moderate to deep pressure on soft tissue has been studied in both humans and non-human animals with positive results shown in reducing anxiety and promoting relaxation. Canine anxiety disorders are often treated with medications and behavior modification programming. Pressure wraps are sometimes used to treat canine anxiety, but the effects of this investigation have not been rigorously investigated. The aims of this study were to investigate the use of a pressure wrap (ThunderShirt®) on heart rate and behavior in dogs diagnosed with anxiety disorder. Subjects were 90 dogs (39 males, 51 females) who were diagnosed with Separation Anxiety or Generalized Anxiety Disorder. Dogs were randomly assigned to one of three groups-Experimental Group 1(Dogs wore the ThunderShirt® per manufacturer's recommendations); Experimental Group 2 (Dogs wore the ThunderShirt® loosely without pressure); Control Group (Dogs had no specific treatment). Average heart rate and maximum heart rate were measured at baseline and after 15 minutes alone in the kennel. Dogs were video-recorded and analysis completed for twelve behaviors: pacing, panting, yawning, tongue-flicking, drooling, elimination, barking, stress whining, howling, licking, door orientation, and calmness. Results: Dogs in Experimental Group 1 showed significantly less increase from baseline in average heart rate than the Control Group dogs (p <0.001) and dogs in Experimental Group 2 (p < 0.001). Dogs in Experimental Group 1did not differ significantly from Control Group dogs in maximum heart rate when all dogs were considered, but did differ significantly from the Control Group (p = 0.04) when only those dogs not currently on anxiety medication were considered. There were no statistically significant differences among groups on behavioral outcomes, except dogs in the Control Group were significantly more likely to orient toward the door than dogs in both Experimental Group 1 (OR = 7.46, p = 0.01) and Experimental

Group 2 (*OR* = 4.42, *p* = 0.04). Dogs in Experimental Group 1 presented a trend of less tongue-flicking (p = 0.06) and yawning (p = 0.07) stress reduction behaviors when compared to the other two groups. More research should be conducted with the ThunderShirt® on behavioral outcomes. The ThunderShirt® can be used with behavior modification programming and medication, as an adjunct treatment option to assist dogs diagnosed with anxiety disorder to reduce heart rate.

Keywords: Canine stress, ThunderShirt®, heart rate, Separation Anxiety, pressure wrap

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1. Introduction

Canine anxiety disorders are common behavior problems seen in veterinary clinics and hospitals across the United States. Treatments for these disorders incorporate medication, behavior modification programs and alternative techniques. One technique, moderate to deep pressure, has been used in humans and animals to reduce tension and anxiety (Diego & Field, 2009; Edelson et al., 1999; Grandin, 1992). The research on moderate pressure massage in humans showed enhanced growth and development in infants as well as stress reduction in adults (Field et al., 2010). The use of pressure to calm animals and reduce stress has been documented in a number of studies (Grandin, 1992; Williams & Borchelt, 2003).

Early research, examining the use of pressure applied to a pig's lateral sides of the body while in a V-shaped trough, showed that pressure promoted relaxation and sleep in the animal (Grandin et al., 1989). Other livestock animals such as cattle, had reactions to being restrained in a squeeze chute that were similar to human reactions in a squeeze machine. The cattle presented calm behavior after feeling the pressure from being in the squeeze chute (Grandin, 1992).

Although the use of pressure has been studied in livestock animals, there has been minimal research on the use of pressure to reduce anxiety and stress in canines. Genetic predisposition to display anxious behaviors is more obvious in prey species, where escape behavior is essential to survive threatening situations, than it is in predatory species, like canines.

The research conducted on the use of pressure in canines had small sample sizes. One study examined the use of pressure with three aggressive Great Danes (Williams & Borchelt, 2003). Each animal was individually restrained in a large wooden box. Approximately 275 kg of triple-cleaned oats were poured over the animal's body to completely immobilize it in a standing position while keeping the head and neck uncovered. Each dog was exposed to a stimulus to which they were reactive (either a human or another dog), with increasing intensity. Each of the dog's aggressive behaviors diminished rapidly during the restraint and resulted in presentation of calm behavior during the highest stimulus intensity (Williams & Borchelt, 2003). The researchers noted a reduced heart rate reading compared to baseline measurement and felt that tactile pressure may be an important tool in behavior modification (Williams et al., 2003).

Another study conducted by Cottam and Dodman (2009) examined the use of a wrap on 23 dogs who were thunder-phobic. The dogs were randomly assigned to an experimental and control group. The experimental group dogs were placed in a Storm Defender Cape® during four different thunderstorm periods. The Storm Defender Cape® is a wrap that has metal-lined fabric to prevent static charges that dogs may experience during a thunderstorm. The control dogs wore a non-antistatic cape during the four different thunderstorm periods. Researchers used owner reports (the owners were not blinded to the study) on how the dogs presented during the thunderstorm looking at specific behavior signs while wearing the cape. Owners completed a 12-question survey and responses were scored examining the severity of behaviors associated with thunderstorm phobia. The use of both cape types was associated with a statistically significant decrease in median anxiety scores from baseline scores. After the cape was used on four occasions, the median anxiety score of the Storm Defender group decreased by 63% from baseline and the non-antistatic cape group's median anxiety score decreased by 36% from baseline. Owners in both groups indicated that their dogs displayed significantly less hiding behavior by the fourth use of the cape. Results from this study indicated the use of a form-fitting cape could be therapeutic in treating canine thunderstorm phobia (Cottam & Dodman, 2009).

Another study conducted by Cottam et al. (2013) researched the Anxiety Wrap® for dogs with thunderstorm phobia. The Anxiety Wrap® is marketed as a pressure wrap that uses gentle, constant pressure to relieve stress and end/lessen fear in these dogs. The research examined a sample of 18 dogs and used owner-reported scores related to use of the Anxiety Wrap® during thunderstorm activity. The mean anxiety scores on the fifth use of the Anxiety Wrap® were 47% lower than the mean anxiety score that was generated before the use of the Anxiety Wrap® (Cottam et al., 2013).

The aim of the present study was to determine the effect a pressure wrap (ThunderShirt®) (ThunderWorks, 905 Jackie Robinson Drive, Durham, NC 27701, USA) has on heart rate and behavior in canines diagnosed with an anxiety disorder.

2. Material and methods

2.1 Animals

A sample of 90 dogs (older than 6 months of age) diagnosed with anxiety [Separation Anxiety (n = 50) or Generalized Anxiety Disorder (n = 40)] by a veterinarian or applied animal behaviorist was referred from veterinary clinics and hospitals along the Front Range of Colorado, United States. There were no breed restrictions for this study. Small, medium and large breed dogs (purebreds and mixes) were used from the following categories: Terrier, Herding, Toy, Working, Sporting, Non-Sporting and Hound Groups. Dogs with any health problems were excluded from the study. IACUC (Institutional Animal Care and Use Committee) approval was granted through the University of Northern Colorado - Office of Sponsored Programs Institutional Review Board. Informed consent was obtained from each canine owner for the dog to participate in the study.

2.2 Experimental Set-up

Dogs were randomly assigned to one of three groups. Experimental Group 1, Experimental Group 2, or the Control Group, with $n = 30$ in each group. Dogs in Experimental Group 1 wore the ThunderShirt® at the level of pressure that it was designed to be worn by the manufacturer (a comfortable but snug fit in which the flaps are secured by Velcro) (Figure 1). Dogs in Experimental Group 2 wore the ThunderShirt® without pressure so that it was just draped over the dog loosely but secured with the

Velcro strap so it stayed on the dog. Dogs in the Control Group received no pressure wrap intervention. Figure 1 shows dog in Experimental Group 1.

The experimental session lasted for fifteen minutes, as was noted in prior studies, to get a good response (Blairs et al., 2007; Grandin, 1992). Each dog had the opportunity to eliminate outside before the experimental session. A heart rate monitor was attached to the dog's chest by a strap to measure heart rate. The proper size ThunderShirt® was fit prior to the experimental session to maintain adequate pressure over the dog's core yet still allow the dog to freely ambulate in the kennel. A one-minute baseline reading was measured (Diaz et al., 2005; Williams et al., 2003). The leashed dog was walked into a single 1.2 meter x 3 meter kennel, well exceeding USDA regulations. The dog was kept in this well-lit, temperature controlled room at Dog Days Training Kennel Facility for the 15 minute duration of the study. The video camera was recording as soon as the dog was placed in the kennel. Each dog was tested individually to eliminate any influence from other subject's behavior during the experiment. The kennel was cleaned with OdoBan® (Clean Control Corporation, 1040 Booth Road, Warner Robins, GA, 31088 USA), an odor eliminator and disinfectant to provide appropriate hygiene and reduce any environmental smell. Kennel facility camera access provided continuous supervision of each dog so safety was maintained. Owners were allowed to watch their dog on camera in another room during the treatment.

2.3 Procedure

1. The owner takes their dog outside on a leash to eliminate.
2. The owner then brings their dog inside of the kennel building. (The kennel is clean and completely empty of all animals.)
3. The Polar heart rate monitor is securely fastened on the dog by the Researcher.
4. The ThunderShirt® is then placed on the dog (depending on what experimental group they were assigned).
5. A one-minute baseline reading is obtained from the dog with the owner present.

6. The dog is then walked on leash to the research kennel by the owner and Researcher. The dog is placed in the kennel and the leash is removed.
7. The video-recorder button is turned on.
8. The Researcher and owner leave the dog alone in the research kennel and walk out of the building.
9. The Researcher and owner go to the building next door and monitor the dog on closed-circuit TV from the kennel facility office.
10. The researcher and owner return to the research kennel and after 15 minutes, the video-recorder is turned off, equipment removed from the dog and then the animal is reunited with the owner.
11. The research kennel is cleaned with Odoban®.

2.4 Heart rate measurement

The Polar FT40® training computer and Polar WearLink® transmitter (Polar Electro Inc., 1111 Marcus Avenue, Suite M15, Lake Success, NY 11042) was used in this study. Heart rate was measured as beats per minute (BPM). A one-minute reading of heart rate (average heart rate and maximum heart rate with statistics computed via the equipment) for baseline measurement was taken (dog with the owner) prior to placement in the kennel. Heart rate measurements obtained from the Polar equipment (average heart rate and maximum heart rate, with both statistics computed over the length of the 15-minute treatment session via the equipment) were recorded at the end of the experimental session (dog alone in room in kennel). The lightweight wristwatch (transmitter) was attached to the dog's collar and a small elastic strap was adequately fitted around the dog's chest with a Velcro attachment. Conduction gel was used to get a good heart rate reading. The transmitter on the dog's collar picked up the signal and stored the result. Heart rate data collection was downloaded to a laptop via the Polar FlowLink® and Polar Websync 2.1 software®. Comparisons of baseline readings and post-treatment session readings were analyzed.

The toy breed dogs were too small for the Polar child-size elastic strap. A small paper clip was used to hold the elastic strap to the dog's chest. The clip was non-intrusive and laid flat against the dog's

back. The electrodes on the elastic strap were placed in the center of the dog's chest, under the dogs forelimbs, where hair growth was thin. Long-haired dogs used more conduction gel than short-haired dogs.

2.5 Behavior measurement

Behavioral signs of anxiety used in this study were those originally indicated as diagnostic criteria for Separation Anxiety by Overall (2013). Canine Separation Anxiety symptoms include: destruction, elimination or vocalization while the dog's owner is away. Canine Generalized Anxiety symptoms include: excessive environmental vigilance, persistent fear, and panic. Behavioral signs were monitored via camera video-recorder. A JVC Everio Camcorder (JVC Professional Products Company, 1700 Valley Road, Wayne, NJ, 07470 U.S.A.) was placed on a tripod approximately 4.5 meters away from the kennel to get a full view of the dog and to avoid prompting any anxiety in the dog. The video-recording was started at the beginning of the treatment session and was terminated 15 minutes afterward. Each dog remained alone in the kennel without any excess environmental stimuli for the duration of the session. Dog treats were available for owners to give their dogs after the end of the session, if they chose. Each dog had the opportunity to be evaluated by an applied animal behaviorist post-treatment session in the event there were any adverse signs of stress after having been in the kennel.

Two investigators reviewed the video data for continuous measurement and logged each anxiety behavior noted during the 15 minute experimental session of the dog in the kennel. Behaviors recorded included: pacing, panting, yawning, tongue-flicking, drooling, elimination, barking, stress-whining, howling, and licking (Butler, 2011; King et al., 2000; Overall et al., 2001; Palestrini et al., 2010; Riva et al., 2008) (see Table 1). Additionally, an interval measurement was scored by the investigators at the 10-minute mark of the video recording. The investigators noted the presence or absence of whether the dog exhibited a calm presentation (dog sitting/lying, being non-vocal) and if the dog orientated toward the environment, specifically, distant visual inspection of the kennel door (Palestrini et al., 2010).

The bivariate correlation between the ratings for the two investigators were generally high for each measure, with an average correlation across all behavioral measures of $r_{average} = 0.99$. When coded

as binary measures (presence vs. absence of the behavior) investigators showed absolute agreement (κ = 1.00) on eight of the ten behaviors with lower agreement on howling (κ =0.96) and licking (κ =0.64). For the non-binary measures (pacing, panting, tongue-licking, elimination, barking, stress-whining, howling, and licking) the ratings for the two investigators were averaged to obtain a single measure of behavioral anxiety for each outcome. The binary ratings of drooling showed absolute agreement between the investigators.

2.6 Statistics

Group differences in heart rate were assessed by using analysis of covariance (ANCOVA) where either average heart rate or maximum heart rate (both described above) served as the repeatedly-measured dependent variable (over the two time points described previous), experimental treatment with three levels (ThunderShirt® worn to specification, ThunderShirt® worn loosely, and no ThunderShirt®) served as the between-subjects factor, and age of the dog in months and anxiety medication status served as control variables. Specifically, the treatment × time effect was assessed, which indicates whether statistically significant group differences were evident in the change in heart rate over the two time points. Follow-up pairwise comparisons of the groups using Bonferroni correction of significance levels were additionally carried out for any statistically significant omnimbus tests. Additionally, η^2, or the proportion of variance in the outcome variable attributable to the factor of interest (Cohen, 1988), was computed to assess the magnitude of significant observed effects. Kruskal-Wallace non-parametric analysis of variance was used to assess experimental group differences on the outcomes of pacing, panting, yawning, tongue-flicking, elimination, barking, stress-whining, howling, and licking. Group differences on calm presentation, and door orientation were assessed using binary logistic regression, where experimental group membership, age, and medication status served as the predictors. For all analyses, an alpha level of 0.05 was used as a criterion for statistical significance. Statistical analyses were conducted using SPSS (2012). (Statistical Package for the Social Sciences, IBM Corporation, 1 New Orchard Road, Armonk, New York 10504-1722, USA).

3. Results

Table 2 provides distributional information about the sample by treatment condition. The mean ages of the dogs were 74.8 months (SD = 43.9), 71.5 months (SD = 40.2), and 53.2 months (SD = 32.7) for Experimental Group 1, Experimental Group 2, and the Control Group, respectively.

Examination of the treatment × time interaction effect in the analysis of covariance (ANCOVA) (Table 3), using experimental group membership as the between-subject factor and age in months and anxiety medication status as the control variables, showed statistically significant overall differences in the change in average heart rate among the three groups [$F(2, 83) = 8.53$, $p < 0.001$] with a large effect size ($\eta^2 = 0.15$).

Follow-up pairwise comparisons of the groups, utilizing a Bonferroni correction of the pairwise *p*-values, indicated that the change in average heart rate among dogs in Experimental Group 1 (ThunderShirt® worn to specifications) differed significantly from dogs in both the Control Group ($p = 0.022$) and dogs in Experimental Group 2 (ThunderShirt® worn loosely; $p = 0.001$). Specifically, Experimental Group 1 dogs decreased in average heart rate, while the other two groups increased. No statistically significant difference was observed between dogs in Experimental Group 2 and the Control Group ($p = 1.00$). (Figure 2) provides a plot of the means (i.e., the means predicted by the ANCOVA model adjusting for age in months) by treatment condition for this outcome.

An additional ANCOVA, with average heart rate as the repeatedly measured dependent variable, experimental group membership as the between-subject factor, and age as a covariate was carried out using only those dogs that were not currently on anxiety medication (see sample sizes in Table 2). Results again showed statistically significant differences among the three experimental groups in their change in average heart rate [$F(2, 69) = 19.76$, $p < 0.01$], with the same pattern of mean values as found in the previous analysis (see Figure 3). Bonferroni-adjusted pairwise comparisons showed that dogs wearing the ThunderShirt® to specifications (Experimental Group 1) differed significantly from both the Control Group ($p < 0.01$) and dogs wearing the ThunderShirt® loosely (Experimental Group 2, $p < 0.01$). No significant difference was evident between Experimental Group 2 and the Control Group ($p = 1.00$).

Similarly, ANCOVA (Table 3) using maximum heart rate as the outcome and dog's age and anxiety medication status as control variables showed statistically significant overall differences among the three experimental groups [$F(2, 86) = 4.51$, $p = 0.01$] with a moderate effect size ($\eta^2 = 0.07$). Here, however, Bonferroni-adjusted pairwise comparisons showed a statistically significant difference between dogs in Experimental Group 1 and dogs in the Experimental Group 2 ($p = 0.02$), with the former showing less increase in maximum heart rate than the latter. When compared to dogs in the Control group, however, dogs in both experimental groups did not differ significantly ($p = 0.15$ and $p = 1.00$ for Experimental Group 1 and Group 2, respectively). Figure 3 provides a plot of means by treatment condition for maximum heart rate adjusted for age in months.

An additional ANCOVA was carried out using only those dogs not currently on anxiety medication. In this analysis, maximum heart rate served as the repeatedly measured dependent variable, experimental group membership as the between-subject factor, and age as a covariate (see relevant sample sizes in Table 1). Results again showed statistically significant differences among the three experimental groups in their change in average heart rate [$F(2, 69) = 3.45$, $p = 0.04$], with a similar pattern of mean values as found in the previous analysis (see Figure 5). Here, however, Bonferroni-adjusted pairwise comparisons showed that dogs wearing the ThunderShirt® to specifications (Experimental Group 1) differed significantly from the Control Group ($p = 0.04$), while no significant difference was evident between Experimental Group 2 and the control group ($p = 0.86$), or between Experimental Group 1 and Experimental Group 2 ($p = 0.35$).

Next, the three experimental groups were compared on the behavioral signs of anxiety. Table 5 shows descriptive statistics for the non-binary behavioral measures (pacing, panting, yawning, tongue-flicking, elimination, barking, stress whining, howling, and licking), while (Table 6) shows frequencies and percentages related to the binary measures of anxiety (drooling, calm presentation, and door orientation).

Because the distributions for a substantial number of the behavioral measures of anxiety shown in (Table 5) demonstrated marked skewness, Kruskal-Wallis non-parametric tests were carried out. Results

showed no statistically significant group differences on any of these behavioral measures (each $p > 0.05$). Logistic regression analyses additionally showed that no statistically significant group differences for the binary outcomes of drooling ($\chi^2(2) = 0.00$, $p = 1.00$), or calm presentation ($\chi^2(2) = 0.06$, $p = 0.74$). Statistically significant group differences were evident, however, for the outcome of door orientation ($\chi^2(2) = 7.62$, $p = 0.02$). Specifically, dogs in the Control Group were significantly more likely to visually orient toward the door than dogs in both Experimental Group 1 ($OR = 7.46$, $p = 0.01$) and Experimental Group 2 ($OR = 4.42$, $p = 0.04$). Table 6 and Table7 summarize the results from these tests.

4. Discussion

The purpose of this study was to address whether the pressure provided by a ThunderShirt® had an effect on canines diagnosed with anxiety disorder. This study examined dogs from multiple breed groups who had been diagnosed with Separation Anxiety or Generalized Anxiety Disorder. Dogs with these diagnoses showed various anxiety symptoms and expressed these signs in varying degrees.

A model of animal stress begins in the central nervous system after an organism perceives a threat or potential threat and the behavioral fight-or-flight mechanisms in the organism are activated in an attempt to adapt or cope with a dangerous situation (Scholz & von Reinhardt, 2007). An animal may be successful in avoiding the stressor through flight or it may find itself in a situation where behavioral options are limited, such as in confinement (Moberg, 2000) and physiological changes will occur. These physiological changes which can occur include: increased heart rate, rapid respiratory rate and reduction of gastrointestinal processes as the organism attempts to deal with the threat and eventually maintain homestasis.

4.1 Heart rate

Heart rate is a useful measure to evaluate stress reactions in dogs (Palestrini et al., 2005). Changes in the environment can be stressful to animals. Separation from a dog's owner can bring about both behavioral and physiological signs indicating stress and anxiety (Flannigan & Dodman, 2001). Based on results, this study showed a significant reduction in average heart rate for dogs experiencing the pressure of wearing the ThunderShirt® versus the dogs who either wore it loosely or didn't wear one

during data collection. When maximum heart rate was examined, dogs wearing the ThunderShirt® to specifications showed significantly less increase in maximum heart rate than dogs wearing the ThunderShirt® loosely, but neither of the treatment groups differed from the control group. However, when only those dogs not currently on anxiety medication were examined, dogs wearing the ThunderShirt® to specifications showed significantly less heart rate increase than dogs in the control group. Consistent with prior studies on the use of pressure, it appeared the ThunderShirt® affected heart rate changes and activated the sympathetic nervous system (arousal in kennel) and parasympathetic nervous system (Grandin, 1992; Williams & Borchelt, 2003).

4.2 Behavior analysis

All of the dogs in the study experienced some level of anxiety during data collection, but not all of them met the minimum operational criteria for anxiety used in this study. For example, although points were only given for those dogs who stress-whined or barked for more than five seconds, many of the dogs stress-whined or barked, but did so for less than five-second episodes. The video investigators, although very consistent in their judgments, noted that increases in dog stress were associated with increased difficulty in their ability to score the behaviors. Some dogs barked in a manner that transitioned into a howl (as noted in prior studies), while others barked and whined at the same time. A few of the dogs faced sideways while in the kennel and although the investigator could see quick expansion and contraction of the chest from breathing (tachypnea), the investigator was unable to view actual open-mouthed panting on the video-recording.

Given that dogs in the Experimental Group 1 showed a marked difference in average heart rate change from dogs in the remaining groups, it was surprising that no significant change was observed for many of the behavioral signs of stress. It is unclear why heart rate reduction was significant in those canines that had the ThunderShirt® worn to manufacturer's specifications (Experimental Group 1), but the majority of behavioral signs of anxiety did not show a significant reduction. The dogs in Experimental Group 1 oriented to the door less frequently looking for an owner, compared to the other two groups.

Orientation toward the door (where owner exited) is a discomfort-related stress behavior (Palestrini et al., 2005; Palestrini et al., 2010). Dogs with Separation Anxiety will often watch the door for owners to return or be destructive around the door space (Overall, 2013; Palestrini et al., 2005). Statistically significant group differences were observed, however, in dogs' visual orientation towards the door. Dogs in both experimental groups showed less likelihood than the control group dogs to exhibit such orientation. Specifically, 90% of the dogs in the Control Group oriented toward the door when the owner left them in the kennel. In contrast, only 53% of the dogs wearing the ThunderShirt® to specifications oriented to the door, while 67% of dogs wearing the ThunderShirt® loosely showed such orientation.

Dogs in Experimental Group 1 presented a trend of less tongue-flicking ($p = 0.06$) and yawning ($p = 0.07$) stress reduction behaviors when compared to the other two groups. The other stress behaviors examined were not significant when examining the three groups. One animal behavior study provided a similar presentation of results when the researchers looked at physiological parameters and behavior. Examination of stress responses in Chinese water deer (*Hydropotes inermis*) showed that manual restraint of hand-reared deer didn't react less violently in behavior but continued to show lowered plasma cortisol levels compared to free-ranging deer who were also manually restrained (Hastings et al., 1992).

Individual personality types and life experiences could also contribute to how dogs react to stressful environments and result in inconclusive behavioral results in this study. Dogs that are generally fearful appraise threats in a range of situations, and it is assumed they often experience negative emotions such as acute fear or anxiety (Svartberg, 2007; p. 190).

It is not uncommon for dogs with Separation Anxiety to eliminate while the owner is away (McCrave, 1991; Overall, 2013). Dogs in this study were allowed to eliminate prior to the experimental session. The video recordings showed dogs defecated in the kennel even though they eliminated beforehand. The dogs who eliminated in the research kennel had loose consistency stools. Research shows dogs in shelters having loose stools can result from stress (Sokolow et al., 2005). There were less

episodes of elimination in the dogs who wore the ThunderShirt® to manufacturer's specifications compared to the other two groups.

No dog required veterinary/behavioral assistance following the study due to increased stress.

5. Conclusion

Results from this study showed dogs who wore the ThunderShirt® to manufacturer's specifications had lowered heart rate, decreased visual orientation towards the door (looking for their owner), as well as trending toward reduced yawning and tongue-flicking stress behaviors. More research, however, is needed on the use of a pressure wrap, and specifically the potential effect a ThunderShirt® may have on behavioral signs of anxiety in canines. The results of the current study suggest that the pressure from the ThunderShirt® has value in heart rate reduction for dogs with Separation Anxiety or Generalized Anxiety Disorder who experience stressful situations. This pressure wrap can be used adjunctively in a treatment program for dogs with these specific anxiety diagnoses, but should not replace current treatment options (behavior modification and medication) for Canine Separation Anxiety and Generalized Anxiety Disorder. Caution must be practiced if using the ThunderShirt® for dogs with phobic reactions to loud noises or thunderstorms, as this hadn't been studied with the canine anxiety diagnoses.

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Table 1
Table of Operational Definitions

Behavior	Point Scale	Definition
Pacing	1 point	Dog walked to one end of kennel and back
Panting	1 point	Behavior present in a five second interval
Yawning	1 point	Each episode observed
Tongue-Flicking	1 point	Each episode observed
Drooling	1 point	Notable frothiness at lip lines or actual drool spilling from mouth (If observed during 15 minute session)
Elimination	1 point	Each episode of urination or defecation observed
Barking	1 point	Behavior present in five second interval
Stress-Whining	1 point	Behavior present in five second interval
Howling	1 point	Behavior present in five second interval
Licking	1 point	Repetitive behavior in five second interval
Calm Presentation	X	Dog is lying or sitting and not vocalizing at the 10-minute point on video-recording-scored as present or absent
Orientation to the Door	X	Dog's visual orientation (to the kennel door the owner exited) at the 10-minute point on video-recording-scored as present or absent

Table 2
Sample Characteristics

	Experimental Group 1		Experimental Group 2		Control Group	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Sex						
Female	16	53.3%	20	33.3%	15	50.0%
Male	14	46.7%	10	67.7%	15	50.0%
Total	30	100.0%	30	100.0%	30	100.0%
Alteration (spayed or neutered)						
Yes	29	96.7%	30	100.0%	29	96.7%
No	1	3.3%	0	0.0%	1	3.3%
Total	30	100.0%	30	100.0%	30	100.0%
Currently on Anxiety Medication						
Yes	9	30.0%	5	16.7%	3	10.0%
No	21	70.0%	25	83.3%	27	90.0%
Total	30	100.0%	30	100.0%	30	100.0%

Table 3

Analysis of Covariance (ANCOVA) Results for Effect of Treatment Group on Average Heart Rate

Source	*SS*	*df*	*MS*	*F*
Time	1411.75	1	1411.75	7.43**
Time × Group	3237.86	2	1618.93	8.53**
Time × Age	128.33	1	128.33	0.68
Time × Medication Status	18.33	1	18.33	0.10
Time × Group × Medication Status	711.89	2	355.95	1.87
Error	15,761.42	83	189.90	

Note. **$p < 0$ .01.

Table 4

Analysis of Covariance (ANCOVA) Results for Effect of Treatment Group on Maximum Heart Rate

Source	*SS*	*df*	*MS*	*F*
Time	13453.84	1	13,453.84	27.07**
Time × Group	4486.46	2	2243.23	4.51*
Time × Age	128.35	1	128.35	0.26
Time × Medication Status	365.72	1	365.72	0.74
Time × Group × Medication Status	1042.54	2	521.27	1.05
Error	41254.66	83	497.04	

Notes. * $p < .05$, ** $p < 0.01$

Table 5
Descriptive Statistics for Behavioral Measures of Anxiety by Experimental Condition

Behavioral Measure of Anxiety	Experimental Group 1			Experimental Group 2			Control Group		
	M	*SD*	Skewness	*M*	*SD*	Skewness	*M*	*SD*	Skewness
Pacing	9.32	25.01	4.16	7.18	7.81	1.33	7.70	9.12	2.00
Panting	19.58	20.92	1.40	26.85	27.15	1.12	25.90	22.94	1.39
Yawning	1.72	3.59	3.65	0.63	1.94	4.27	2.07	4.39	2.86
Tongue-flicking	11.35	18.01	3.65	15.75	15.18	0.99	17.43	16.42	1.32
Elimination	0.03	0.18	5.48	0.10	0.31	2.81	0.13	0.43	3.50
Barking	6.33	14.18	2.83	7.67	21.64	2.96	5.07	11.66	3.33
Stress-whining	11.18	21.55	2.12	13.93	21.21	2.59	20.32	24.02	0.90
Howling	1.95	4.16	2.36	1.47	6.44	5.22	2.88	7.59	2.80
Licking	0.05	0.20	4.28	0.10	0.40	4.28	0.58	1.79	4.08

Table 6

Frequency and Percentage of Dogs Showing Drooling, Calm Presentation, and Door Orientation Behavior

	Experimental Group 1		Experimental Group 2		Control Group	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Drooling	7	23.3%	7	23.3%	6	20.0%
Calm Presentation	17	56.7%	15	50.0%	14	46.7%
Door Orientation	16	53.3%	20	66.7%	27	90.0%

Note. $n = 30$ in each experimental group.

Table 7
Results for Kruskal-Wallis and Logistic Regression Analyses for Group Differences on Behavioral Measures of Anxiety

	Kruskal-Wallis test			Logistic regression		
Outcome	χ^2	*df*	*p*	Wald χ^2	*df*	*p*
Pacing	3.39	2	.18	--	--	--
Panting	1.39	2	.50	--	--	--
Yawning	5.32	2	.07	--	--	--
Tongue-flicking	5.52	2	.06	--	--	--
Elimination	1.25	2	.54	--	--	--
Barking	0.17	2	.92	--	--	--
Stress-whining	2.82	2	.25	--	--	--
Howling	3.31	2	.19	--	--	--
Licking	3.79	2	.15	--	--	--
Drooling	--	--	--	0.00	2	1.00
Calm Presentation	--	--	--	0.59	2	.74
Door Orientation	--	--	--	7.62	2	.02

Figure 1. Subject in Experimental Group 1 wearing ThunderShirt® according to manufacturer's specifications.

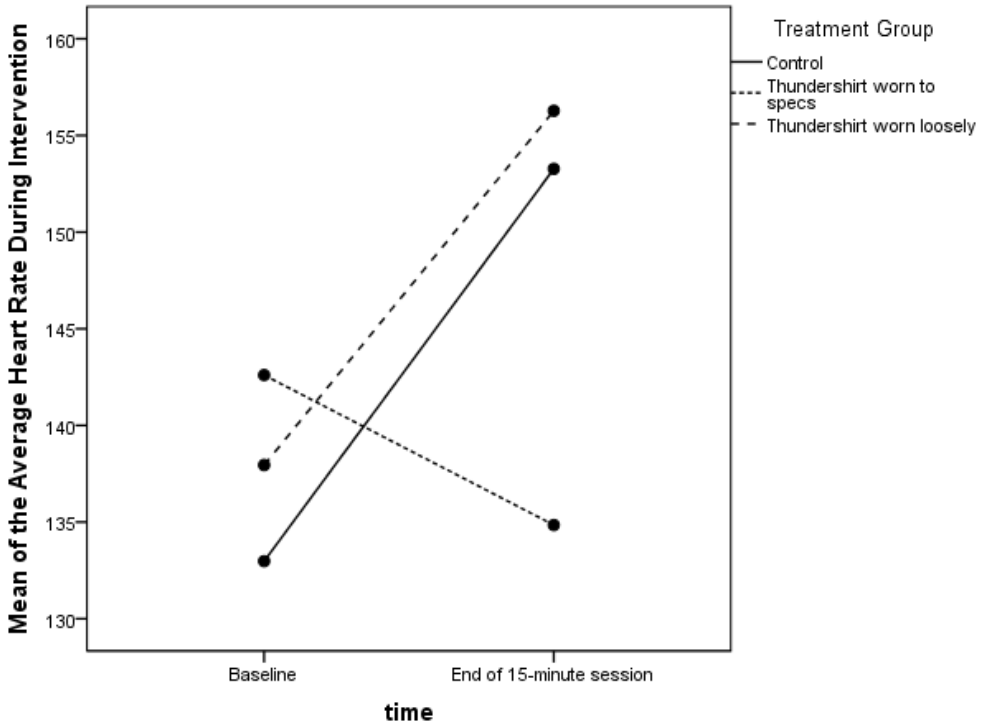

Figure 2. Plot of adjusted means for average heart rate during intervention by treatment condition. Means are adjusted for mean value of the covariate (age = 66.5 months).

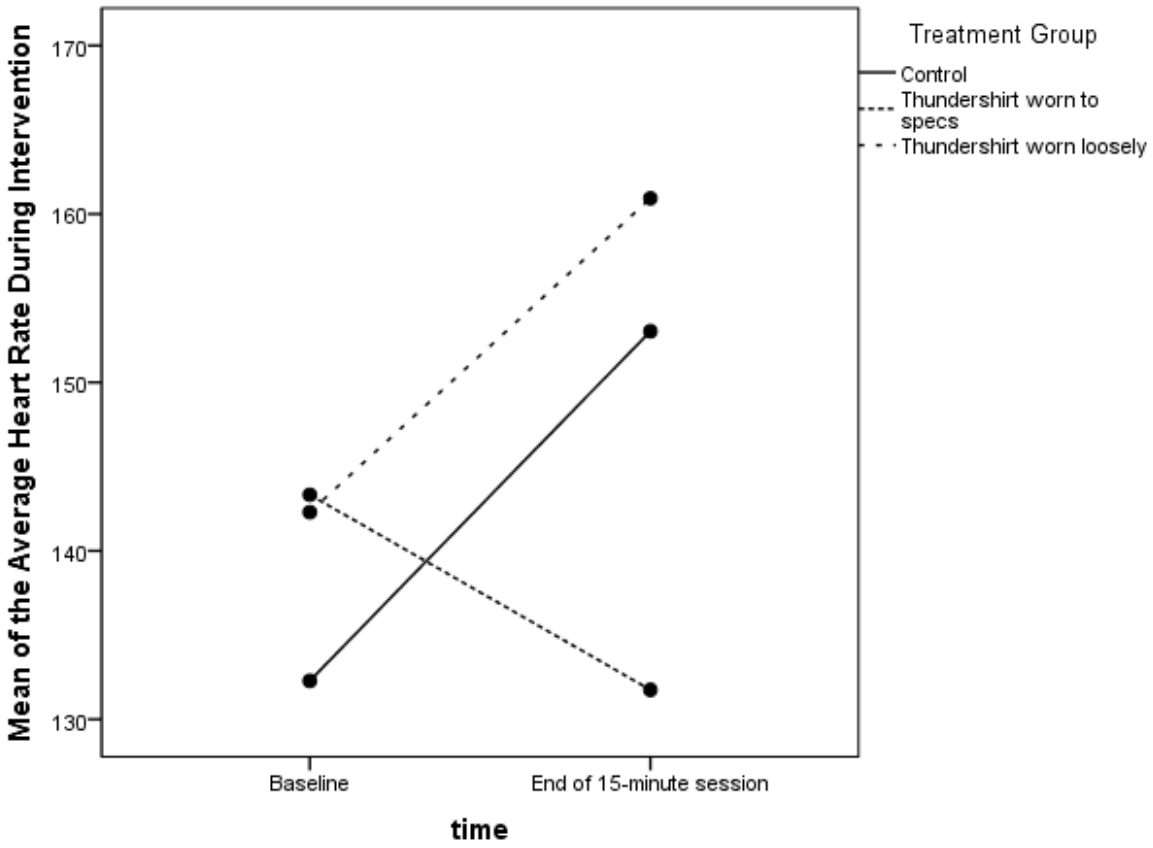

Figure 3. Plot of adjusted means for average heart rate during intervention by treatment condition (dogs not on anxiety medication only). Means are adjusted for mean value of the covariate (age = 62.7 months).

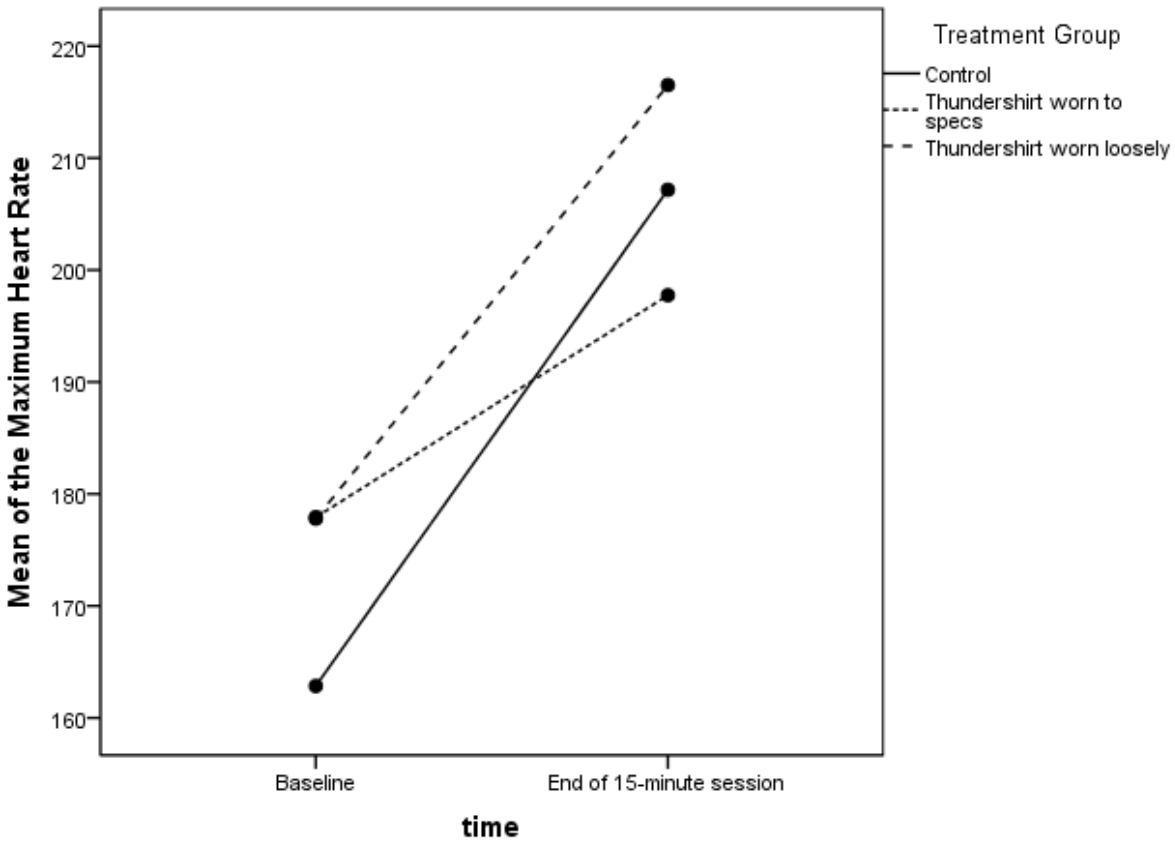

Figure 4. Plot of adjusted means for maximum heart rate during intervention by treatment condition. Means are adjusted for the mean value of the covariate (age = 66.5 months).

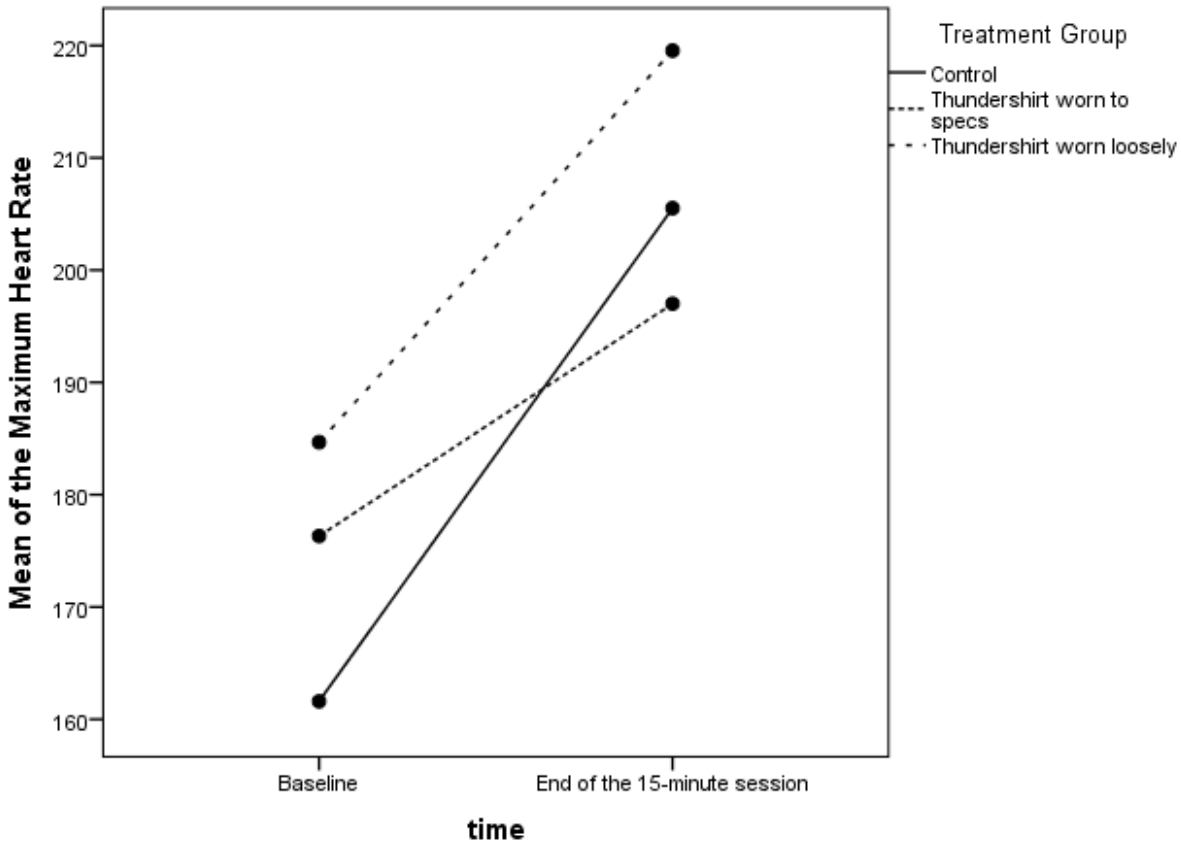

Figure 5. Plot of adjusted means for maximum heart rate during intervention by treatment condition (dogs not on anxiety medication only). Means are adjusted for the mean value of the covariate (age = 62.7 months).

H I G H L I G H T S

- There was a significant reduction in heart rate in dogs who wore a pressure wrap
- Behavioral signs of anxiety among groups were not statistically significant
- Dogs who wore a pressure wrap exhibited less orientation toward a door