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Animal Visitation Program (AVP) Reduces Cortisol Levels of University Students: A Randomized Controlled Trial

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*University students report high levels of stress. Although causal work is limited, one popular approach to promote stress relief is animal visitation programs (AVPs). We conducted a randomized trial (*N *= 249) examining effects of a 10-minute AVP on students' salivary cortisol levels. Undergraduate students were randomly assigned to one of four conditions: hands-on AVP (petting cats and dogs;* n *= 73), AVP observation (watching others pet animals;* n *= 62), AVP slideshow (viewing images of same animals;* n *= 57), or AVP waitlist (*n *= 57). Participants collected salivary cortisol upon waking, and two samples were collected 15 and 25 minutes after the 10-minute condition, reflecting cortisol levels at the beginning and end of the intervention. Controlling for students' basal cortisol, time awake, and circadian pattern, students in the hands-on condition had lower posttest cortisol compared to slideshow ($\beta = .150$, $p = .046$), waitlist ($\beta = .152$, $p = .033$), and observation ($\beta = .164$, $p = .040$). A 10-minute college-based AVP providing hands-on petting of cats and dogs provides momentary stress relief.*

Keywords: *randomized controlled trial, stress prevention, cortisol, human-animal interaction, university, college*

Over the past decade, university students have reported increasingly high levels of academic stress, depressive symptomology, anxiety, and suicidal ideation (Bayram & Bilgel, 2008; Keyes et al., 2012). This is a serious problem as students who report these symptoms tend to have lower GPAs and are more likely to drop out of college (Eisenberg, Golberstein, & Hunt, 2009). One approach to stress prevention that has been enthusiastically received by administrators and students is the use of animal visitation programs (AVPs). Established in nearly 1,000 U.S. college campuses to date (Crossman & Kazdin, 2015), most AVPs provide the general student population an opportunity to engage in hands-on petting of animals for 5 to 45 minutes in small group settings. While some of these programs are ad hoc in nature, such as university staff bringing their personal pets to campus (Thomson, 2003), others use formal approaches ranging from providing interaction with specially trained therapy dog–handler teams (Barker, Barker, McCain, & Schubert; 2016; Binfet, 2017; Binfet & Passmore, 2016; Binfet, Passmore, Cebry, Struik, & McKay, 2017) to providing interaction with adoptable animals from local shelters (Baran, 2003; Cavazos, 2010), which may include dogs, cats, and other species.

Conceptualized as preventive interventions to promote student well-being, most AVPs are implemented with a universal focus to serve the general student population rather than taking a selective or indicated approach to target individuals possessing risk factors to develop a particular disorder. Although the number of randomized controlled trials (RCT) is limited, there is promising evidence to suggest that participating in AVPs results in higher ratings of momentary positive emotions, a reduction in stress-related negative emotions (Pendry, Carr, Roeter, & Vandagriff, 2018), lower perceived stress (Barker et al., 2016; Binfet, 2017; Crossman, Kazdin, & Knudson, 2015), and improvements in mood (Grajfoner, Harte, Potter, & McGuigan, 2017). That said, there are several gaps in knowledge about the effects of various intervention components such as dosage, type of interaction, animal species and training, role of the handler training, and outcomes most affected.

One might assume that the implementation of AVPs on college campuses is a consequence of the prevailing model guiding preventive intervention research—the preventive intervention research cycle (Mrazek & Haggerty, 1994). According to this perspective, prevention programs are first developed with a comprehensive theoretical and empirical understanding of the target issue, then tested for efficacy under tightly controlled research conditions, examined in real-world settings for effectiveness in broader populations, and finally disseminated for public implementation. However, this is not the case for university-based AVPs, which enjoy widespread implementation prior to dissemination of causal research demonstrating their effects. The omission of this important step provides a unique and valuable opportunity for prevention researchers to examine effects of existing programs in real-life settings (Gottfredson et al., 2015).

This observation is also timely given a comprehensive review of human-animal interaction (HAI) research in educational settings (Gee, Griffin, & McCardle, 2017) and a call for further research in this journal. In their proposed theoretical model, Gee and colleagues (2017) posit that animal involvement in educational settings may lead to students' enhanced social-emotional development through various paths, including motivation and/or self-efficacy toward learning, engagement and/or attention to educational activities, self-regulation and coping with academic stress, and social interaction with other humans. The authors specifically called for a more comprehensive, rigorous evidence base to inform policies and practices for HAI interventions in educational settings, including college-based AVPs. The present study responds to this call by examining the extent to which participation in a college-based AVP may affect a *physiological* component of college students' self-regulation and coping with academic stress as marked by salivary cortisol levels.

Because AVPs are promoted on college campuses as effective stress relief programs, examining whether participation in AVPs affects salivary cortisol levels, a marker of the hypothalamic-pituitary-adrenal (HPA) axis—one of the body's most sensitive stress-systems—is warranted for the following reasons. First, based on the observed links between periods of heightened stress, elevations in basal cortisol, dysregulation of diurnal patterns, and the emergence of psychopathology, heightened HPA-axis activity is hypothesized to play a role in the development of stress-related disorders (Lupien, McEwen, Gunnar, & Heim, 2009). As such, aiming to reduce HPA-axis activity and facilitate adaptive regulation through AVPs is a sound goal. Second, there is evidence to suggest that AVPs may affect HPA-axis activity through modulation of the oxytocin system (Beetz, Unväs-Moberg, Julius, & Kotrschal, 2012). In fact, significant increases in oxytocin (OT) levels in human plasma have been found after as little as 3 minutes of physical interaction with a dog (Handlin et al., 2011). Because increases in OT are associated with decreases in cortisol (Legros, Chiodera, Geenen, & von Frenckell, 1987; Petersson, Lundeberg, & Unväs-Moberg, 1999), engagement in AVPs—and the observed increases in OT—may suppress HPA activity. Third, although no studies have shown significant effects of group-based AVPs on college students' salivary cortisol, there is evidence to suggest a significant stress-buffering effect during individually focused canine interaction in college students (Barker, Knisely, McCain, & Best, 2005). In addition, while not based on causal work with college students, there is evidence that within-person, momentary "downregulation" of cortisol can be achieved in response to interactions with dogs (Odendaal & Meintjes, 2003). Last but not least, given the strong evidence to suggest causal effects of visiting therapy dogs on college students' perceived stress (Barker et al., 2016; Binfet et al., 2017; Binfet & Passmore, 2016), examining an outcome strongly associated with perceived stress—cortisol—may demonstrate that the shown effects of human-canine interaction on perceived stress and well-being are not merely mediated by the belief in the efficacy of human animal interaction, namely, the perception and belief of participants that dogs reduce stress, but are possibly mediated by objective physiological changes in HPA-axis activity, which could shed light on potential mechanisms underlying effects of HAI on stress-related outcomes. Examining whether exposure to 10 minutes of HAI effectively reduces cortisol is thus a sound first step.

The overall objective of this study was to examine the effectiveness of an existing, universal, college-based AVP in momentarily downregulating college students' salivary cortisol levels. To meet this objective, this study was conducted during a real-life implementation of a well-established prevention program during which college students were provided with an opportunity to physically interact in supervised group settings with shelter dogs and cats brought to campus by the humane society. While the majority of animal visitation programs conducted on college campuses feature dogs, the incorporation of cats and other animals is not unusual. In a geographically representative survey of college-based AVPs, Haggerty and Mueller (2017) reported 86% of sampled programs featured dogs only, while 5% feature cats and dogs, and 10% use dogs, cats, and other species, including rabbits, baby goats, and alpacas, among others. While no RCTs have been conducted on the effects of a program incorporating cats on college student stress and mental health functioning, both live cats (Holt, Johnson, Yaglom, & Brenner, 2015) and stuffed toy cats (Thodberg et al., 2016) have been incorporated into published research conducted on AVPs in nursing home populations. Moreover, laboratory studies suggest petting a cat may improve mood in female undergraduate students (Kobayashi, Yamaguchi, Ohtani, & Ohta, 2017) and among cat owners living alone (Rieger & Turner, 1999; Turner & Rieger, 2001).

Since university administrators planned implementation according to procedures already developed and employed over three semesters prior to the study team's involvement, we collaborated with them to facilitate inclusion of an embedded causal research design rather than merely conduct a program evaluation examining within-person changes in program participants. As such, in addition to randomly assigning students to the condition experienced by regular *program* participants, 10 minutes of supervised petting of shelter cats and dogs, researchers randomly assigned *study* participants to conditions created specifically to mimic and isolate inherent, often overlooked AVP components: (a) the experience of waiting in line for an extended period of time while in or outside the visible range of human animal interaction and (b) experiencing various levels of socialization with other humans. The dosage of a total of 10 minutes was informed by a discussion with program implementers, who identified that in prior semesters, most students engaged with animals for approximately 10 minutes. They also indicated program staff actively managed student entry and exit to accommodate a large number of participants rather than allowing students to determine the length of exposure. This is not an unusual expectation given prior evidence suggesting students will, if given the chance, choose to engage with program animals for an average of 35 minutes (Binfet et al., 2017).

To capture unique program effects of what is considered the most popular feature of college-based AVPs—freely touching and petting animals—the study team compared students' salivary cortisol levels in response to 10 minutes of hands-on petting of cats and dogs, 10 minutes of waiting in line while observing other students interact with animals, 10 minutes of visual exposure to still images of the same program animals, and 10 minutes of waiting for program access without visual or physical exposure to program animals. We hypothesized that students in the hands-on condition would experience most significant stress relief as evidenced by most pronounced reductions in salivary cortisol levels after the intervention than those in other conditions. The estimated effects of participation in the comparison conditions are thus examined to isolate the distinct contributions of the *physical* components of human animal interaction on salivary cortisol levels, separate from contributions incurred by socializing with peers, aspects of visual exposure, or neither. Although these features are inherently part of most AVPs, increasing our understanding about the unique contributions of these key components will guide whether the physical component—petting—during AVPs is a necessary causal condition or whether socialization with peers or viewing animals may be sufficient.

Methods

This study was conducted at a research university in the Pacific Northwest of the United States over the course of three semesters. Procedures were conducted in accordance with the ethical standards of the Institutional Research Committee and the 1964 Helsinki declaration. The PI of the study and all graduate-level research assistants completed the Animal Awareness Seminar and the Animal Contact Program Tutorial, and all Institutional Animal Care and Use Committee (IACUC) procedures were followed following institution approval.

Recruitment and Sample Characteristics

Recruitment took place the week before final exams, a few days before program implementation, coinciding with a university-wide announcement of the AVP program date and location by the Office of the Dean of Students. Given the universal orientation of the program, we conducted in-class recruitment presentations targeting students (N = 547) enrolled in general education classes. The recruitment presentations contained information about the time, date, and procedures of the AVP program; the study protocol and related salivary sampling procedures; and salivary sampling demonstrations. Only students who confirmed their availability during planned program times were eligible for study participation. Eligible students were consented by the PI and completed a survey on relevant demographic characteristics (e.g., age, standing, number of credits, major, GPA, and stress-related symptoms). Each survey featured a randomized treatment condition identifier meaningless to participants indicating the treatment condition to which they were randomly assigned ($N_{\text{hands-on}} = 73$; $N_{\text{slideshow}} = 62$; $N_{\text{observation}} = 57$ $N_{\text{waitlist}} = 57$). For a flow diagram describing recruitment, screening, condition allocation, reasons for declining participation, and study completion, see Figure 1.

Participants (N = 249) were primarily White (n = 153, 63.1%), female ($N_{\text{female}} = 208$), underclassmen ($N_{\text{freshman}} = 81$, $N_{\text{sophomore}} = 60$, $N_{\text{junior}} = 67$, $N_{\text{senior}} = 38$, $N_{\text{unknown}} = 3$), with mean age of 19.94 years (SD = 1.66) and an average GPA of 3.08 (SD = 0.44). We assessed depressive symptomology (Beck Depression Inventory; Beck, Steer, & Brown, 1996), from which a composite score was calculated (N = 249; M = 9.47, SD = 7.04; range, 0–46), showing most participants as *minimally depressed* (0–13; N = 182) or *mildly depressed* (14–19; N = 46), some *moderately depressed* (20–28; N = 15), and some *severely depressied* (29–63; N = 16, 6.4%). Assessment of participant anxiety (Beck Anxiety Inventory; Beck & Steer, 1993) showed that the majority of participants had *minimal* (N = 98) or *mild* anxiety (N = 87), with some showing *moderate* (N = 41) and *severe* (N = 23; 9.2%) anxiety. Rates of clinical depression and anxiety in our study sample were comparable to rates of symptomology described in the American College Health Association (2018) National College Health Assessment showing 22.1% of students with diagnosed or professionally treated anxiety and 18.1% with depression. The mean level of participant *worry* (Penn State Worry Questionnaire; Meyer, Miller, Metzger, & Borkovec, 1990) was 52.74 (SD = 12.64), and mean level of *perceived stress* (Perceived Stress Scale–10; Cohen, Kamarck, & Mermelstein, 1983) was higher (M = 18.59, SD = 6.39) than normed mean levels of perceived stress for individuals 18 to 29 years in the general population (M = 14.4, SD = 6.2; Cohen et al., 1983). Students with clinically relevant symptoms received a sealed, personalized letter containing information about on-campus resources along with a suggestion that they may benefit from professional referral or consultation. Participant variables of the complete study sample and those by condition are provided in Table 1.

Dependent Variable: Postintervention Salivary Cortisol

To accurately calculate treatment effects on posttest levels of salivary cortisol, we employed a salivary sampling paradigm assessing both diurnal and momentary cortisol activity (Adam, 2006) for the following reason. Approximately 62% to 72% of variation in cortisol levels is explained by diurnal patterns, with the remaining portion thought to reflect momentary influences (Adam & Gunnar, 2001). A typical, healthy diurnal rhythm for cortisol is observed as a moderate output slightly before and around awakening that rises to a peak within 30 minutes of waking, followed by a rapid decline within the next few hours that slows to a steady but increasingly slow decrease until nighttime, when levels reach a nadir within the first few hours of sleep (de Lacerda, Kowarski, & Migeon, 1973; Schmidt-Reinwald et al., 1999; Van Cauter, 1990; Weitzman et al., 1971). While brief interventions such as 10-minute AVPs are hypothesized to affect the portion of a sample's value reflecting momentary reactivity, we controlled for possible influences on the variation in participants' diurnal cortisol patterns since basal cortisol and dysregulation of diurnal patterns, namely, positive or flat slopes, may influence momentary responses. As such, we first describe how salivary cortisol was collected, beginning with the wakeup sample. Next, we describe the sampling paradigm to capture cortisol reactivity in response to treatment conditions by describing the salivary sampling procedures at pretest and posttest. Once collection, storage, and assaying have been outlined, we describe the calculation of parameters modeled.

Collection of Wakeup Cortisol

On the day of the intervention, which occurred within 2 days after recruitment, participants collected a salivary cortisol sample on their own immediately upon waking (Stalder et al., 2015), from which basal levels and diurnal slopes toward pretest cortisol levels were calculated. To accommodate in-home sampling, participants were given take-home sampling kits containing written saliva sampling instructions, a cryovial, straw, labels containing their study ID number, permanent pen, and a short survey to report physical activity, food and beverage intake, medication use, and exposure to animal interaction. During the recruitment meeting, participants observed a demonstration, practiced taking a sample, and received thorough verbal and written instruction to take a wakeup sample immediately upon waking (before moving, ingesting anything, or brushing their teeth) using the passive drool method and thereafter marking their exact sampling time. Participants were instructed to store their completed sampling kit in the refrigerator, not freezer, until study check-in. On the day of the study, during check-in procedures, staff collected participants' take-home sampling kits and inquired about their sampling compliance. They also reminded participants not to eat or drink until pre- and posttest sampling was completed.

Collection of Salivary Cortisol Reflecting Pretest and Posttest Levels

In measuring cortisol reactivity to discrete events, it is important to consider the timing of sample collection in relation to the events to which reactivity is measured. Given that cortisol is reflected in saliva 25 minutes following the onset of a stressor event, a sample taken at any given time reflects one's cortisol levels 25 minutes prior to that sample. Participants thus provided a sample 15 minutes after the conclusion of their 10-minute condition to reflect cortisol levels at the start of their condition (pretest cortisol; Gunnar & Adam, 2012; Kirschbaum & Hellhammer, 1989) as well as a sample 25 minutes after completion to reflect cortisol levels at the end of their 10-minute condition (posttest cortisol). Sampling took place in a designated sampling area where participants also completed a checklist to document behavior that day pertinent to sampling, such as use of medication; food and beverage intake; caffeine, nicotine, and alcohol intake; exercise; and interactions with animals before program participation.

Saliva samples were stored in coolers on icepacks until research assistants completed an electronic record of samples and stored samples in freezer-safe storage boxes designed for this purpose. Samples were visually inspected for debris and blood contamination, then stored at −80°C in a laboratory freezer until shipment to a specialized laboratory. Cortisol levels were assayed using a competitive solid phase time-resolved fluorescence immunoassay with fluorometric endpoint detection (DELFIA; Dressendörfer, Kirschbaum, Rohde, Stahl, & Strasburger, 1992) with an intraassay coefficient of variation between 4.0% and 6.7% and interassay coefficients between 7.1% and 9.0%, respectively.

Condition Descriptions

Participants randomly assigned to the hands-on condition ($N = 73$) were directed to a curtained off program entry area where research assistants timed students' entry and exit into the program area, located in a large gym. Upon entry, four to five students engaged with dogs under supervision of a handler, whereas they engaged with cats individually. Dogs ($N = 16$; $N_{\text{female}} = 9$), adult, large breed shelter animals, were seated on blankets and leashed in close proximity of their handler. Cats ($N = 14$; $N_{\text{female}} = 9$) were housed in large cat condos, which facilitated individual interactions. Students freely interacted with animals, engaging in petting and stroking.

Participants assigned to the observation condition ($N = 62$) were first directed to a curtained-off area adjacent to the hands-on condition. The observation condition tested effects of an often overlooked component of AVPs: the experience of waiting in line for their turn in the program. Oftentimes, a large line of participants accumulates throughout the duration of the event, usually in visible and audible

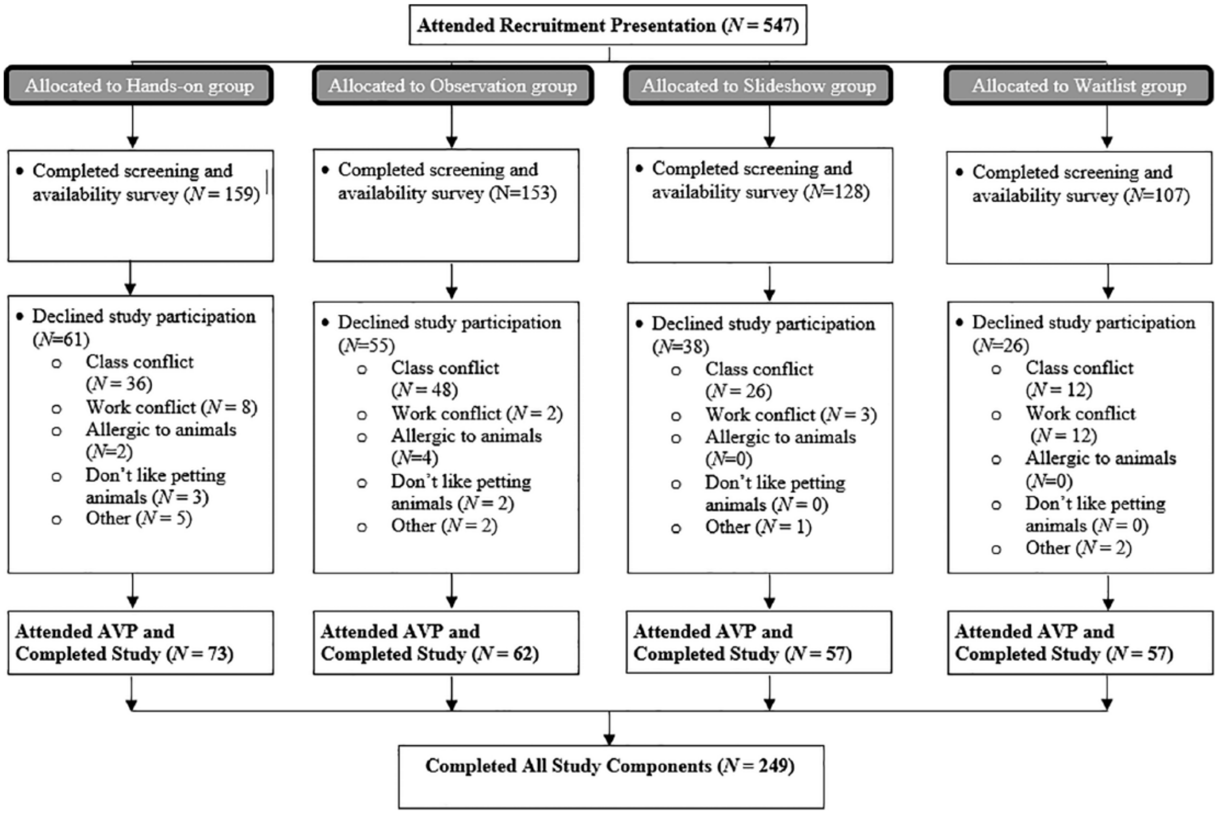

FIGURE 1. *Flow diagram describing recruitment, screening, and reasons for declining study participation.*

range of program animals; whether this component exerts an effect on students remains uninvestigated. In addition to the fact that varying implementation practices may lead students to be exposed to different aspects of the program, the observation condition poses a challenge to researchers trying to impose control to isolate effects of varying program components. Upon entry, staff instructed participants that they could observe others engage in human animal interaction, and although participants were in proximity of 8 feet to 10 feet, they were asked to refrain from engaging in physical interaction with animals and remain behind the roped barrier.

Participants in the slideshow condition (N = 57) were escorted to a room where they viewed a 10-minute slide presentation containing pictures of the same program animals while indicating their preferences on a checklist (e.g., which dog/cat do you like best). Participants were instructed to refrain from interacting with other participants. This comparison condition was intended to isolate the effect of viewing visual depictions of the program cats and dogs without the component of social interactions with peers or physical interaction with the animals. The waitlist condition (N = 57) was designed to examine effects of waiting quietly for 10 minutes without exposure to common program stimuli. Participants were led to a waiting room and asked to store cell phones and reading materials and instructed to refrain from verbal interaction with others. Students in the comparison conditions were reassured they would experience animal interaction once their data had been collected. Students were given 1% extra credit in the class from which they were recruited and a free pizza coupon after completing the intervention as well as priority status to enter the animal interaction area.

Handler and Animal Selection, Training, and Observation of Stress-Related Behavior

It is important to note that the current study began as an evaluation of an existing program implemented by university administrators in collaboration with a local animal shelter for three semesters prior to our research team's involvement. All interactions were supervised by professional handlers of the local Humane Society and their director, who was on site throughout the study. Professional handlers were trained shelter employees experienced and knowledgeable about animal care and interaction in general as well as familiar with animals selected for this program. The director of the shelter and the PI developed handler-student interaction guidelines encouraging a focus on facilitation of safe physical interaction and conversations about the animal (i.e., age, breed, history, etc.) rather

TABLE 1

Sample Characteristics by Group

	Hands-on (*N* = 73)	Observation (*N* = 62)	Slideshow (*N* = 57)	Waiting (*N* = 57)	Final sample (*N* =249)
	M (*SD*)/*n* (%)	*M* (*SD*)/*n* (%)	*M* (*SD*)/*n* (%)	*M* (*SD*)/*n* (%)	*M* (*SD*)/*n* (%)
Demographics					
Age	20.33 (1.61)	19.15 (1.27)	20.28 (1.64)	19.93 (1.85)	19.94 (1.66)
Female	60 (82%)	47 (75%)	49 (86%)	52 (91%)	208 (84%)
White	45 (62%)	39 (62%)	38 (67%)	35 (61%)	157 (63%)
Black or African American	5 (7%)	2 (3%)	4 (7%)	4 (7%)	15 (6%)
Hispanic or Latino	10 (14%)	4 (6%)	6 (10%)	6 (11%)	26 (10%)
Native Hawaiian/other Pacific Islander	0 (0%)	2 (3%)	0 (0%)	0 (0%)	2 (1%)
Multiracial	6 (8%)	11 (17%)	2 (4%)	3 (5%)	22 (9%)
American Indian or Alaska Native	0 (0%)	0 (0%)	1 (2%)	1 (2%)	2 (1%)
Asian American	3 (4%)	4 (6%)	3 (5%)	4 (7%)	14 (6%)
Other	2 (3%)	0 (0%)	1 (2%)	3 (5%)	6 (2%)
Academic Standing					
Freshman	17 (23%)	34 (56%)	11 (20%)	19 (33%)	81 (33%)
Sophomore	21 (29%)	16 (26%)	11 (20%)	12 (21%)	60 (24%)
Junior	21 (29%)	9 (15%)	19 (34%)	18 (32%)	67 (27%)
Senior	14 (19%)	2 (3%)	14 (26%)	8 (14%)	38 (15%)
Cumulative GPA	3.03 (.39)	3.12 (.49)	3.10 (.43)	3.11 (.48)	3.08 (.44)
Current semester credits enrolled	15.08 (1.64)	14.41 (1.99)	15 (1.82)	14.56 (1.71)	14.78 (1.8)
Mental health symptomology					
Depression	8.95 (6.89)	9.06 (7.69)	10.68 (6.65)	9.40 (6.93)	9.47 (7.04)
Anxiety	12.30 (9.70)	9.79 (7.73)	12.75 (10.17)	11.6 (10.02)	11.62 (9.45)
Worry	52.92 (12.34)	50.27 (12.72)	55.09 (11.99)	53.6 (12.3)	52.91 (12.39)
Perceived stress	18.8 (5.58)	17.8 (6.56)	19.88 (6.58)	18.32 (6.25)	18.69 (6.23)
Do any pets live in your household?					
No	43 (59%)	33 (52%)	31 (54%)	36 (63%)	143 (57%)
Yes (total)	30 (41%)	29 (46%)	26 (46%)	21 (37%)	106 (43%)
Yes (cat)	11 (15%)	23 (37%)	12 (21%)	10 (18%)	56 (23%)
Yes (dog)	25 (34%)	20 (32%)	17 (30%)	17 (30%)	79 (32%)
Would you describe yourself as a . . .					
Cat person	8 (11%)	7 (11%)	10 (18%)	6 (11%)	31 (12%)
Dog person	46 (63%)	38 (60%)	27 (47%)	26 (46%)	137 (55%)
Both	17 (23%)	17 (27%)	18 (32%)	23 (40%)	75 (30%)
Neither	1 (1%)	0 (0%)	2 (4%)	1 (2%)	4 (2%)

Note. Percentages are rounded to the closest whole percent.

than engaging in verbal interactions with students that might lead into discussions about mental health issues. We also identified a procedure to respond to instances where students behaved in ways that raised concerns about student mental health or animal safety. Fortunately, no events warranted the execution of this protocol.

The director and handlers selected animals based on their age and suitability to safely interact with two, three, or four students at a time for a 10-minute period. Evaluation assessed the dog's reaction to various types of handling and potentially fear-producing stimuli. Dogs had demonstrated responsiveness to their handler, friendly body language, acceptance of human interactions in a pleasant manner, no unacceptable attention-seeking behaviors like pawing or jumping, minimal distress signals and rapid recovery from fear-inducing noises and sounds, and no history of aggression toward people or other animals. Additionally, each dog was house trained, physically healthy, and up to date on vaccinations. Animals were leashed using harnesses, buckle collars, head collars, and leashes no more than 6 feet in length.

To ensure animal safety and well-being during the study, the following IACUC procedures were followed. Humane Society personnel facilitated setup of appropriate stations for the cats and dogs and reviewed the overall safety of the program space. Animals were brought on campus by professional handlers chosen by the Humane Society director. The animals were always leashed and under direct supervision of their handler, who had approximately 30 minutes to an hour to become acclimatized to their surroundings. Animals were taken on scheduled walks, although the needs for each animal were addressed on an individual basis, so animals could be taken for a walk at any time if needed. After each 10-minute interaction, animals experienced a “break” lasting 1 to 5 minutes before being introduced to new participants. This break could be extended as needed based on the animals’ welfare and behavior during the interaction. Water was available at all times.

In addition, the research team was joined by two animal behavior specialists who were leaders of a regional community partner of Pet Partners, a national certifying organization for therapy dog teams, and experienced evaluators and trainers of canine behavior according to Pet Partners protocol (Pet Partners, 2016). Together, we developed an animal behavior stress checklist to document animal behavior in situ, procedures to identify distressed animals, and guidelines for communicating those concerns to the director of the shelter. Using this checklist, we also developed “exit procedures” for affected animals during the program if necessary and set up a schedule of intermittent breaks and walks, presence of water, use of blankets and toys, and identifying inappropriate dog-directed student behavior. Dog specialists documented behavior independently but simultaneously over 2-minute periods throughout the program, rotating between handler-dog teams, resulting in ongoing monitoring of each animal.

Results

We first conducted a one-way ANOVA with a Bonferroni correction to test for between-group differences on all components of the screening survey. No significant differences by group were found except for class standing, $F(3, 242) = 10.641$, $p < .001$, $\eta^2 = .12$, and age, $F(3, 242) = 7.023$, $p < .001$, $\eta^2 = .08$. Next, we examined missing ($N = 3$) and extreme values ($N = 3$) of waking cortisol. Given significant correlations between wakeup and pretest values, $r(245) = .74$, $p < .001$, and evidence that pretest values of participants with missing wakeup samples were within one standard deviation of the sample mean, we replaced missing wakeup cortisol for those participants with sample mean wakeup values. Extreme cortisol values ($N = 3$) were winsorized to three standard deviations above their respective sample means (Schlotz et al., 2008; $M = .19$, $SD = .70$). A natural logarithmic transformation for each cortisol parameter at each time point was used to reduce positive skew, as is the recommended practice (Stalder et al., 2015). Next, we tested for between-group differences in cortisol levels at pretest while controlling for time of day and total time awake to account for expected systematic variance due to the variability in condition start times. We found no group differences, $F(3, 239) = 5.281$, $p = .002$, $\eta^2 = .02$, indicating that groups started their respective 10-minute conditions with comparable cortisol levels.

Intervention Effects on Posttest Cortisol

To examine intervention effects on posttest cortisol levels, multivariate linear regression analyses were conducted on natural log-transformed, winsorized posttest cortisol values (see Table 2). First, intervention variables dummy-coded with the hands-on group as the reference category entered into the regression model with a test of significance at $\alpha = .05$ (see Table 2, Model 1). Results of the initial model indicate that those who participated in the slideshow ($\beta = .224$, $p = .004$), observation ($\beta = .293$, $p < .001$), and waiting ($\beta = .236$, $p = .002$) conditions exhibited significantly higher cortisol levels at posttest compared to those in the hands-on condition.

Extending the previous model, several covariates were entered into the model (see Table 2, Model 2) for the following reasons. As mentioned previously, when modeling cortisol levels in the context of a study examining treatment effects, it is extremely important to account for the fact that approximately 70% of variation in cortisol levels at any given time of day for any given individual is explained by an individual’s diurnal or circadian pattern, with only the remaining portion reflecting momentary influences such as those “caused” by potential treatment effects (Adam & Gunnar, 2001). Since we are modeling cortisol values in an experimental design in which the timing of the start of the 10-minute intervention varied within groups and between groups, we aimed to capture participants’ pretest and posttest cortisol levels at varying time points along their diurnal curve. In fact, rather than examining differences in absolute values of momentary cortisol, we measured differences in posttest cortisol for each participant compared to what would what be expected for that time of day for that individual by including sampling time, the slope of diurnal pattern for that individual, and the total hours awake until the start of the intervention.

Given that the outcome variable, posttest cortisol, was logarithmically transformed, the coefficients predicting this outcome can be interpreted as a percent change in the outcome per unit change in the independent variable by applying an antilog transformation to the raw, unstandardized B coefficient ($B_{\%\text{change}} = [\exp(B_{\text{raw}}) - 1]$). Results indicated that wakeup cortisol levels ($\beta = .297$, $p < .001$) and total time awake from wakeup to posttest ($\beta = -.166$,

$p = .016$) were significantly associated with posttest cortisol levels as expected, given the contribution of diurnal indices to a given momentary sample. Furthermore, participants in the slideshow ($\beta = .150$, $p = .046$, $B_{\%\text{change}} = 27.01\%$), observation ($\beta = .164$, $p = .040$, $B_{\%\text{change}} = 29.24\%$), and waiting ($\beta = .152$, $p = .033$, $B_{\%\text{change}} = 27.66\%$) conditions demonstrated significantly higher posttest cortisol levels than those in the hands-on condition. Trajectories of cortisol levels modeled by group over the three sampling periods clearly illustrate significant differences in posttest cortisol levels by condition as illustrated by lower levels in the hands-on group, see Figure 2.

To explore the magnitude of these differences between comparison conditions, we conducted a one-way ANOVA with a Bonferroni correction comparing natural log-transformed posttest cortisol levels across all four groups. We found significant differences, $F(3, 243) = 6.061$, $p = .001$, between the observation group ($M = -1.848$, $SD = .605$) and the slideshow ($M = -1.961$, $SD = .524$; $p = .006$) and waitlist ($M = -1.981$, $SD = .906$; $p = .001$) groups, while levels in the waitlist and slideshow groups were equivalent ($p = >.999$), suggesting that observing others enjoy human-animal interaction in relatively close proximity without touching the animals appears to have stress-relieving effects in its own right. This has implications for program implementers conducting such programs, who may want to consider allowing participants to wait for their turn in a broader treatment space with easy visual and audible access to program animals.

Discussion

This study shows that students randomly assigned to participate in 10 minutes of hands-on interaction with cats and dogs from a local shelter exhibited significantly lower salivary cortisol levels at posttest compared to those who waited in line while observing others engage in HAI, watched still images of the same animals, and waited quietly without external stimuli. While the present study is the first causal examination of a university- and group-based AVP on university students' salivary cortisol levels, it complements work by Polheber and Matchock (2013), who found a stress buffering effect on salivary cortisol in college students who performed the Trier Social Stress Test (TSST) in the presence of a therapy dog compared to students who completed the TSST alone or with a friend. Given that one-on-one and group interactions with animals have reduced individuals' cortisol levels in therapeutic and health care settings in the past (Barker et al., 2005; Handlin et al., 2011), our results add to the evidence for the efficacy of brief, universal, university-based animal visitation programs to reduce university students' physiological stress.

Given that posttest cortisol levels were lowest in the hands-on group, which involved 10 minutes of petting and socializing with cats and/or dogs, and second lowest in the observation group, which involved the visual, audio, and social aspects of the hands-on experience without the opportunity to physically interact with the dogs, it is possible that a mechanism by which hands-on petting lowers students' cortisol levels is through increases in OT. However, this is not likely to be a complete explanation of program effects. It is likely that perceptual and psychological mechanisms are involved in the stress-relieving effects of this program as well. The perception of animals' capacity in providing social support and effective stress relief, or expectancy, may in itself play an important role in modulating HPA-axis activity in the AVP context. Since appraisal of stressors is a key component in the process of coping with stress (Cohen & Wills, 1985; Lazarus & Folkman, 1987), the belief that animals provide an effective coping source may encourage individuals in stressful situations to appraise their stress as less threatening or aid management of emotions in response to stress. In fact, research suggests that participants are willing to engage in animal-assisted interventions (AAIs) and believe the experience will be helpful to them (Rabbitt, Kazdin, & Hong, 2014). Also, the notion that interaction with animals constitutes an instrumental source of social support conducive to relieving stress in humans is widely supported by HAI researchers and clinicians. Many individuals perceive that their pets provide emotional support, perhaps more readily than fellow humans (McNicholas & Collis, 2000). In addition, since a sense of belonging is thought to lead to increased perceptions of social support (Cohen & Wills, 1985), interactions with animals, and the social facilitation of human interaction that may co-occur in the AVP context, are likely to contribute to humans feeling supported (McNicholas & Collis, 2000). Furthermore, the presence of animals is found to affect humans' appraisal of other humans, such as faculty and professors (Wells & Perrine, 2001), psychotherapists (Schneider & Harley, 2006), and possibly fellow students. In addition, physical contact—a feature central to the hands-on condition—is regarded as an expression of social support, which when combined with emotional support has been found to be most effective to reduce autonomic and endocrine stress responses (Ditzen et al., 2007). As such, it is reasonable to suggest that participation in hands-on AVPs may influence individuals' appraisal of stressors as less threatening and facilitate physiological downregulation, which are important modulators of HPA-axis activity. While it is beyond the scope of our study to extrapolate these findings to impacts on academic achievement, these findings fit nicely into the theoretical model posed by Heissel, Levy, and Adam (2017) in this journal linking HPA-axis activation to academic achievement, whereby both diurnal and momentary HPA functioning affect students' test performance.

TABLE 2

Multivariate Regression Analyses Predicting Posttest Cortisol (µg/dl)

	B	*SE*	β	*t*	*p*	Interpretation
Model 1 ($R^2 = .080$)						
(Constant)	−2.339	.080		−9.121	<.001*	ŷposttestcort = .096 µg/dl[a]
Whether observation	.493	.126	.293	3.896	<.001*	+63.08% if observation[b]
Whether slideshow	.356	.121	.224	2.952	.004**	+42.39% if slideshow[b]
Whether waiting	.381	.122	.236	3.120	.002**	+45.96% if waiting[b]
Model 2 ($R^2 = .143$)						
(Constant)	−1.509	.198		−7.629	<.001**	ŷposttestcort = .221 µg/dl[a]
Whether observation	.259	.125	.164	2.063	.040*	+29.24% if observation[b]
Whether slideshow	.241	.120	.150	2.005	.046*	+27.01% if slideshow[b]
Whether waiting	.246	.115	.152	2.142	.033*	+27.66% if waiting[b]
Wakeup cortisol value	.274	.077	.297	3.536	<.001**	2.65% increase for every 10% increase in wakeup cortisol value
Cortisol slope wakeup to pretest	1.338	.656	.169	2.041	.042*	281.14% increase for every 1-unit increase in slope
Hours awake to posttest	−.064	.026	−.166	−2.119	.016*	6.20% lower for every 1 hour awake

Note. All cortisol values natural log transformed.

[a] Due to the logarithmically transformed outcome variable (i.e., natural log of cortisol values), the inverse function of that transformation (i.e., exponential function) was applied to return this intercept to its value on the original scale of measurement.

[b] Special properties of a logarithmic outcome variable allow coefficients predicting that outcome to be interpreted as % change in the outcome per unit change in the independent variable after the following transformation has been applied to the *B* coefficient: $B_{\%\text{change}} = [\exp(B_{\text{raw}}) - 1]$.

*$p \leq .05$. **$p \leq .01$.

Strengths and Limitations

The current study has several strengths. First, this study featured a randomized design in a real-life setting, a large sample of participants representative of the general student population, and three meaningful comparison groups. This approach speaks directly to calls in the literature (Crossman & Kazdin, 2015; Gee et al., 2017) for sound, causal research designs to examine AVPs' efficacy, particularly with its inclusion of conditions that capture real-world aspects of AVP implementation under tight researcher control. This design allows us to investigate important questions about different aspects of the AVP experience as implemented on a college campus as opposed to laboratory settings or in comparison to a no-intervention control. Specifically, this design allows us to indicate relative contributions of key components of AVPs to the observed findings, demonstrating that the act of physical touch is more important to promoting physiological stress relief than merely observing animals, observing fellow students interact with animals while waiting in line, or waiting without social or visual stimulation.

Second, we simultaneously modeled parameters of diurnal and momentary cortisol, which provides a robust estimate of program effects with consideration to individuals' HPA functioning. By modeling both aspects of HPA-axis activity, we reduce the influence of potential dysregulation of HPA-axis activity as well as contributions of diurnal patterns, which are known to influence momentary cortisol reactivity. Finally, the inclusion of a comparison group that captures the experience of waiting in line with others for the program—an integral component of AVPs—is a unique feature of the present study, which lends evidence suggesting that while watching the AVP with others is less potent than engaging in hands-on interaction, it may provide some stress relief. Given that program implementers must make decisions about the conditions leading up to students' actual participation in the context of a large group of eager participants, the results indicate that waiting in line while observing others may benefit participants. However, it must be noted that these findings only extend to a universal student population who waited in line for 10 minutes; without further research, we cannot assume that the effects of waiting in line while observing such a program will be similar in a more targeted sample featuring highly stressed students or in conditions featuring longer waiting periods.

A limitation is the generalizability of our sample. Although the sample included students from 37 majors across all class standings, the sample was dominated by female underclassmen who chose to participate in the program, suggesting selection may play a role. The same caveat has been noted in nearly all causal work on the effects of university-based AVPs to date. Future work should describe the characteristics of students who attend university-based AVPs to compare the generalizability of these studies' samples to their intended population. In addition, the nature of the AVP under examination must be considered. It was not possible to estimate the contributions of small-group interactions with canines versus individual interactions with felines to the observed outcomes. Given that the embedded study examined contributions of HAI with both species

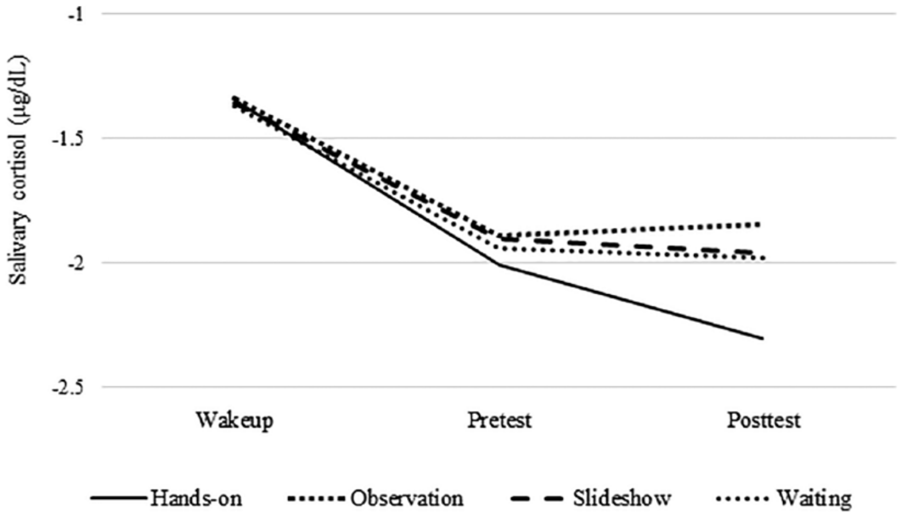

FIGURE 2. *Trajectory of predicted levels of salivary cortisol by condition.*
Note. Presented cortisol values are standardized and natural log-transformed (μg/dL). Predicted values were modeled by including sampling time as a covariate for each parameter. Final model statistics (see Table 2, Model 2) were used to predict posttest cortisol.

simultaneously, our ability to generalize findings to college-based AVPs in general needs to be considered. In addition, the AVP was conducted with shelter animals rather than specially trained therapy dogs, featuring handlers that had not received special training in the facilitation of human-animal interactions. While there is anecdotal evidence to suggest that many college-based AVPs use animals from local shelters, the findings must be considered in that context. It is possible that professional facilitators and their therapy dogs engage in different types of interactions, which may yield different results. In fact, the present study did not capture the nature of the social interactions with fellow students, handlers, or the animals themselves; petting frequency; animal-directed gaze; or the quality of interaction between handlers and students. Future work should aim to distinguish these facets of the program experience to understand the extent to which interacting with animals, as well as other humans in the program, informs program results.

Implications and Contribution

This RCT demonstrates that petting animals during a 10-minute, college-based animal visitation program featuring shelter cats and dogs lowered salivary cortisol levels of students compared to those who merely observed, watched still images of the same animals, and waited without external stimuli. Results suggest college-based AVPs may provide effective stress relief.

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