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Examining Differences between Homebound Older Adult Pet Owners and Non-pet Owners in Depression, Systemic Inflammation, and Executive Function

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ABSTRACT Homebound older adults are prone to depression, which is linked to systemic inflammation that promotes executive function decline. A companion animal may reduce the negative biobehavioral processes associated with depression, inflammation, and reduced executive function in homebound older adults. The primary aim of this study was to examine differences between homebound older adult pet owners and non-pet owners in depression, salivary C-reactive protein (CRP), and executive function. The secondary aim was to determine if the level of attachment to pets was associated with depression, salivary CRP, and executive function. The study was cross-sectional and investigated homebound older adult pet owners and non-pet owners (n = 88) using psychometrically reliable and valid instruments (Geriatric Depression Scale Short Form and CLOX 1). Salivary CRP was assessed with immunoassay. Level of attachment to pets was measured using a Likert scale (0–10). Mean age for the total sample was 75 years (SD = 9). Forty-eight (55%) participants owned pets (56% dogs, 25% cats, 4% other pets, 15% both cats and dogs). Pet owners reported a high level of attachment to pets (Median = 10). Pet owners had significantly higher executive function than non-pet owners (t = –2.07; p = 0.04) but there were no significant differences in executive function between cat owners and dog owners (t = 1.53; p = 0.14). Pet owners and non-pet owners were similar in depression (t = –1.80, p = 0.08) and salivary CRP levels (t = 0.27, p = 0.79). Level of attachment to pets was significantly and positively correlated with executive function (r = 0.30; p = 0.04) but was not significantly correlated with depression (r = 0.04, p = 0.77) or salivary CRP (r = –0.04, p = 0.80).

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Compared with non-pet owners, pet owners had better executive function but similar depression and salivary CRP levels. Reasons for these findings are unclear. Significant positive correlation between pet attachment and executive function suggests further investigation in this area. Future studies with larger samples and a longitudinal design are needed to investigate the biobehavioral changes over time in relation to pet ownership, level of attachment to pets, and executive function in homebound older adults.

Keywords: depression, executive function, inflammation, older adult, pet ownership



Homebound older adults are prone to feelings of depression leading to increased inflammation, which can ultimately decrease executive function and functional independence. Maintenance of executive function is particularly important to the homebound older adult because executive function underpins the maintenance of daily living activities and functional independence, and is strongly predictive of disability (Cahn-Weiner, Boyle and Malloy 2002; Royall et al. 2005; Johnson, Lui and Yaffe 2007). Investigating potential support systems that reduce depression and systemic inflammation and improve executive function may impact independent living for homebound older people.

A companion animal may reduce the negative biobehavioral processes associated with depression, inflammation, and reduced executive function in the homebound older adult. Although no research has been conducted specifically among homebound older adult pet owners, research shows that older adults in nursing homes with pets have lower levels of depression (Crowley-Robinson, Frenwick and Blackshaw 1996; Le Roux and Kemp 2009) and adults exposed to pets have improved immune responses (e.g., salivary Immunoglobulin A [IgA]) (Charnetski, Riggers and Brennan 2004). There is no clear empirical evidence for pets enhancing executive function in pet owners, but pets have been cited to stimulate cognitive development (Poresky et al. 1987) and improve memory indirectly through stress attenuation (Gee et al. 2014). The lack of research among homebound older adult pet owners, coupled with evidence that pets reduce depression, improve immune responses, and potentially improve cognitive development and memory in other populations, justifies the need for further research.

Depression, Inflammation, and Pets

Depression is common in the older adult, particularly among those who experience interpersonal conflicts, health-related disability, death of family or friends, and social isolation (Hardy, Concato and Gill 2002; Seplaki et al. 2006; Kaneko et al. 2007). Major depression is marked by a variety of behavioral symptoms including sadness, irritability, decreased interest or pleasure, fatigue, feelings of worthlessness or guilt, and thoughts of death or suicide (American Psychiatric Association 2013). Homebound older adults are at high risk for depression related to social isolation, functional disability, and financial hardship (Choi et al. 2010).

Depression is associated with dysregulation of the hypothalamic pituitary adrenal (HPA) axis and immune system, which promote systemic inflammation and cellular aging (Epel 2009). Persistent hypercortisolism and increased resistance of glucocorticoid receptors fail to down-regulate inflammatory responses, leading to prolonged pro-inflammatory cytokine production and systemic inflammation (Penninx et al. 2003, Schneiderman, Ironson and Siegel 2005, Stewart et al. 2009). As such, systemic inflammation is linked to a variety of disorders such as depression, infections, autoimmune disorders, coronary artery disease, and poor executive function (Cohen, Janicki-Deverts and Miller 2007; Wersching et al. 2010; Wium-Andersen et al. 2013).

The association between pets and depression in the homebound older adult is underexplored, and findings in the adult population are mixed. Parslow et al. (2005) reported that pet owners aged 60–64 years who lived in the community had higher depressive symptoms than non-pet owners, when controlling for marital status and relationship status. On the contrary, other researchers investigating long-term care and nursing home residents, who may share similar functional decline as homebound older adults, found residents who were exposed to repeated short-term visits with dogs, or who resided with a resident dog, had decreased depression (Crowley-Robinson, Fenwick and Blackshaw 1996; Le Roux and Kemp 2009). For example, Crowley-Robinson, Fenwick and Blackshaw (1996) reported significant decreases in depression over time among older adult nursing home residents who had a resident dog present for 15 months, and Le Roux and Kemp (2009) reported significant improvements in depression over time among physically disabled long-term care residents who interacted with a therapy dog once a week for 6 weeks. Although human–animal interactions and populations varied, these mixed findings suggest older adults who are functionally limited and socially isolated may benefit more from a pet when compared with higher functioning community-dwelling older adults.

Few studies have investigated the effects of pets on inflammatory or immune responses. Charnetski, Riggers and Brennan (2004) investigated salivary IgA responses, an immunoglobulin that is a first line defense against pathogens, and found positive immune responses among participants who were instructed to pet a dog. Researchers compared salivary IgA responses of adults who were instructed to pet a dog with petting a stuffed dog or sitting quietly, and reported significant pre–post increases in salivary IgA levels in the dog group only. These findings suggest brief interactions with pets enhance positive immune responses. In addition, large-scale studies have suggested pet ownership may be associated with reduced cardiovascular disease risk in conditions that are hypothesized to be related to inflammation. The American Heart Association published a scientific statement, suggesting that pet ownership, particularly dog ownership, was likely to be associated with decreased cardiovascular risk (Levine et al. 2013). C-reactive protein (CRP) is an independent risk factor for cardiovascular disease (Lagrand et al. 1999) and an established marker of inflammation; thus, CRP could be a potential biological indicator of positive health in pet owners and warrants more research.

Executive Function, Inflammation, and Pets

Executive function involves complex, higher-order processing that includes planning, mental flexibility and abstract formation, problem solving, inhibiting inappropriate actions, attending to relevant sensory information, and ignoring irrelevant sensory information (Kahokehr, Siegert and Weatherall 2004; Alvarez and Emory 2006). Executive function impairment can affect one's ability to carry out activities of daily living including dressing, bathing, and toileting (Royall et al. 2007), and instrumental activities of daily living including preparing meals, handling finances, using public transportation, and shopping (Marshall et al. 2011). Although executive function decline can be a normal consequence of aging, age-related declines are largely variable and are likely attributed to a range of psychosocial, biological, health-related, lifestyle, and environmental factors (Glisky 2007). Active lifestyles, for example, are generally associated with better executive control (Colcombe and Kramer 2003).

Pro-inflammatory cytokines are hypothesized to directly and negatively impact cognitive processes by affecting synaptic plasticity, neurogenesis, and neuromodulation (McAfoose and Baune 2009). CRP is regulated by pro-inflammatory cytokines (Pepys 1981; Bataille and Klein 1992), and high levels of it have been found to increase the permeability of the blood brain

barrier in animal models (Hsuchou et al. 2012). Specifically among community-dwelling older adults, higher CRP levels have been associated with poor executive function (Wersching et al. 2010). Further, the link between high CRP and loss of brain volume has been supported in large population-based studies such as the Framingham Heart Study (Jefferson et al. 2007) and the 3C-Dijon Study (Satizabal et al. 2012). These findings suggest that systemic inflammation is associated with anatomical changes in the brain (Jefferson et al. 2007; Satizabal et al. 2012) and associated executive function deficits (Schram et al. 2007; Wersching et al. 2010).

Although companion animals are suggested to stimulate cognitive development through verbal stimulus in children who are bonded to their pets (Poresky et al. 1987) and improve memory indirectly through stress attenuation (Gee et al. 2014), to our knowledge no studies have reported the relationship of companion animals on executive function outcomes. The potential impact of pets on cognitive function outcomes, coupled with the lack of research, indicates a clear need for investigation.

Attachment to Pets

It has been suggested that the human–animal bond is more profound as one ages (Suthers-McCabe 2001); however, the health benefits of attachment to pets in the older adult are not well understood and the findings have been mixed. For example, researchers of one study found loneliness was lower among older women who reported higher levels of attachment to pets (Krause-Parello and Gulick 2013), whereas other researchers have found that high levels of attachment to pets were associated with higher levels of depression in rural, older adult dog owners (Miltiades and Shearer 2011). These mixed findings suggest the need to further examine the relationship between attachment to pets and psychosocial outcomes.

Oxytocin is a powerful neuropeptide associated with attachment that transmits biochemical information to multiple places in the brain (Uvnäs-Moberg 2003). It is thought to reduce depressive symptoms (McQuaid et al. 2014), attenuate pro-inflammatory cytokine responses in humans (Clodi et al. 2008), and stimulate neurogenesis in animal models (Leuner, Caponiti and Gould 2012). Researchers suggest that oxytocin is an underlying mechanism that affects the psychosocial, neuroendocrine, and biological effects of human–animal interactions (Beetz et al. 2012). Evidence that owners who are attached to their pets release oxytocin when they are present with them (Miller et al. 2009; Handlin et al. 2011) suggests a potential role of attachment relationships on psychosocial and biological responses and health outcomes.

Objectives

The primary aim of this study was to examine differences between pet owners and non-pet owners in depression, salivary CRP, and executive function in homebound older adults. The secondary aim was to determine if the level of attachment to pets was associated with depression, salivary CRP, and executive function. It was hypothesized that pet owners would have lower depression and salivary CRP levels and higher executive function than non-pet owners, and higher attachment to pets would be related to lower levels of depression, salivary CRP, and higher executive function.

Methods

Study Design

A cross-sectional study with homebound older adults was conducted using psychometrically reliable and valid instruments to assess depression and executive function. Saliva was collected to assess salivary CRP, a marker of systemic inflammation.

Sample and Setting

The study was conducted with participants who were receiving home-delivered meals from the Meals on Wheels Association of America Senior Nutrition Program (MOW) in a rural county of over 1,000 square miles. MOW is a federally funded program that delivers meals to homes of older adults in the United States to help meet basic food needs and help older adults remain in their homes (MOW 2015). To qualify for MOW, seniors are required to be ≥ 60 years and without access to adequate nutrition, primarily due to physical and/or mobility limitations (MOW 2015). Inclusion criteria for the current study were 1) ≥ 60 years of age, 2) ability to read/understand English, 3) not diagnosed with a neurodegenerative disease at the time of the study, and 4) currently enrolled in the Meals on Wheels program in a rural county in the southern United States. Exclusion criteria were 1) inability to complete psychometric instruments as instructed, 2) inability to provide saliva samples, and 3) currently taking hormone replacement therapy or corticosteroids. For participants who owned pets, the pet species and the number of pets were not limited.

Potential participants were made aware of the study by recruitment flyers delivered to all older adults receiving MOW; approximately 500 MOW clients. Interested participants called the researcher directly and made an appointment for consent and data collection. The researcher met the participant at their home, confirmed eligibility, obtained informed consent, and collected data; this continued until 88 participants completed the study. A $10 incentive was provided for participation. With a total sample size of 88 (48 pet owners and 40 non-pet owners), the study had 80% power to detect a medium effect size (Cohen's d = 0.61; Cohen 1988).

Data Collection Procedures

Psychometric and biological data were collected between the hours of 1300 and 1700 to control for potential circadian rhythmicity of the biomarker. Participants refrained from eating, drinking, and oral hygiene one hour prior to saliva collection. Prior to collection, participants washed their mouths with water, waited 5–10 min, and then provided a passive drool saliva specimen (approximately 1–2 ml). Specimens were placed in a cooler and transported to a bioscience laboratory where they were stored at –80oC until batch-assayed.

The study was approved by the Institutional Review Board of the University of Texas Health Science Center at Houston.

Measures

Baseline demographic data were collected for descriptive purposes. Valid and reliable psychometric questionnaires were used to assess depressive symptoms and executive function and a Likert scale was used to measure attachment to pets. The salivary biomarker was assessed using an enzyme immunoassay (EIA) kit (Salimetrics, LLC, State College, PA, USA).

For pet owners, the level of attachment to their pets was assessed using a one-item Likert scale (0–10), with higher scores reflecting higher attachment. This was selected as an alternative to a longer pet attachment scale to reduce participant burden (multiple questionnaires and saliva collection).

The Geriatric Depression Scale (GDS) Short Form was used to measure depressive symptoms. The GDS is specifically designed for the older adult and addresses depressive symptoms experienced in the prior week. It is composed of 15 items, with scores ranging from 0 to 15, and higher scores indicate higher levels of depressive symptoms (Yesavage et al. 1983; Sheikh and Yesavage 1986; Burke, Roccaforte and Wengel 1991). Although primarily a screening tool, scores > 5 indicate depression (Marc, Raue and Bruce 2008). The GDS is reliable in older adults (Boss et al. in press); in the current study, Cronbach's α was 0.79.

Salivary CRP is a widely utilized and reliable non-invasive biomarker of inflammation, showing moderate to strong correlation ($r = 0.72$, $p < 0.001$) with serum CRP levels (Ouellet-Morin 2011). To evaluate precision of the salivary biomarker, the intra-assay coefficient of variation (CV) was calculated from the duplicates, and inter-assay CV was calculated from controls on different plates. *A-priori* criterion for intra-assay CV was < 10%, and inter-assay CV was < 15% (Salimetrics, LLC, State College, PA, USA). In the current study, intra-assay CV was 7.1%, and inter-assay CV was 6.9%.

Executive function was assessed using the CLOX 1, which is a clock-drawing task (Royall, Cordes and Polk 1998). Participants were given specific verbal instructions to draw a clock and were graded using a standardized graded criterion. The maximum score is 15, and a score of 10 or less indicates executive function impairment (Royall, Cordes and Polk 1998). The CLOX 1 is reliable in older adults (Boss et al. in press); in the current study, Cronbach's α was 0.83.

Data Analysis

Descriptive statistics were computed for all variables by group (pet owner, non-pet owner). CRP data were log-transformed prior to analysis to better approximate to a normal distribution. Comparisons of continuous variables between the groups were conducted with the *t*-test for independent samples. The chi-square test was used for categorical comparisons between the groups; the Fisher exact test was used when any expected cell counts were < 5. Correlations between the pet attachment scores and other variables were determined by calculating Spearman rank-order correlation coefficients. Statistical analyses were conducted using SAS 9.4 for Windows (Cary, NC, USA) and p values ≤ 0.05 were considered significant.

Results

Characteristics of the Participants

Eighty-eight participants were recruited and all completed the study. The mean age for the total sample was 75 years ($SD = 9$). Forty-eight of the participants (55%) owned at least one companion animal, and of these 56% owned dog(s) only, aside from two who also owned a bird. Twenty-five percent of pet owners owned cat(s) only, 4% owned a bird or guinea pig only, and 15% owned at least one dog and at least one cat, one of whom also owned a bird and fish. Participants were mostly female (66%), Caucasian (94%), widowed (33%) or divorced (30%), with a high school education (78%) and high BMI (≥ 30). No significant differences were found between pet owners and non-pet owners in terms of demographic variables (see Table 1).

Differences between Pet Owners and Non-pet Owners

Table 2 summarizes levels of depression, salivary CRP, and executive function in the pet owners and non-pet owners. One significant difference was that pet owners had significantly higher executive function than non-pet owners. There were no significant differences between cat owners (ownership of a cat or cats, and no dog) and dog owners (ownership of a dog or dogs, and no cat) in level of executive function. Pet owners reported higher depressive symptoms (GDS) than non-pet owners, but the difference was not statistically significant. The levels of CRP were similar between pet owners and non-pet owners.

Attachment to Pets

Pet owners reported a high level of attachment to their pet(s) (Median = 10, Mode = 10). Thirty-five out of the 48 pet owners (73%) rated their attachment to pets as 10 out of 10. The pet

Table 1. Characteristics of the pet owners (*n* = 48) and non-pet owners (*n* = 40).

Demographic	Pet Owners *M* (*SD*)/*n* (%)	Non-pet Owners *M* (*SD*)/*n* (%)	*t* or Chi-square Value	*p*
Age (years)	74.35 (9.02)	76.63 (9.02)	1.18	0.24
BMI	30.60 (6.62)	29.19 (8.16)	–0.90	0.37
Education (years)	11.96 (2.05)	12.90 (2.39)	1.99	0.05
Gender			1.14	0.29
Female	34 (71%)	24 (60%)		
Male	14 (29%)	16 (40%)		
Marital Status			0.73	0.40
Married	16 (33%)	10 (25%)		
Widowed, divorced, single	32 (67%)	30 (75%)		

Table 2. Mean (*SD*) scores for depression, systemic inflammation, and executive fucntion for the pet owners (*n* = 48) and non-pet owners (*n* = 40).

	Pet Owners	Non-pet Owners	*t*	*p*	Effect Size*
Depression (GDS)	5.09 (3.38)	3.85 (3.05)	–1.80	0.08	0.39 (small)
Inflammation (salivary CRP pg/mL)	5,034.74 (9,066.71)	7,468.79 (16,299.64)	0.27	0.79	0.06 (small)
Executive Function (CLOX 1)	10.93 (2.81)	9.59 (3.21)	–2.07	0.04	0.44 (small)

*Cohen's *d.*

attachment score was significantly and positively correlated with the CLOX 1 score ($r = 0.30$; $p = 0.04$), but was not significantly correlated with GDS scores ($r = 0.04$, $p = 0.77$) or CRP levels ($r = -0.04$; $p = 0.80$).

Discussion

Diferences between Pet Owners and Non-pet Owners

The hypothesis that pet owners would have higher executive function than non-pet owners was supported; however, there were no significant differences in levels of depression and systemic inflammation (salivary CRP) between the two groups. Executive function for pet owners was within normal parameters, whereas executive function for non-pet owners reflected impaired executive function (Royall et al. 1998). Lack of differences in depression and systemic inflammation do not explain the potential mechanisms influencing the differences found in the level of executive function between pet owners and non-pet owners, thus the reasons for why pet owners had higher executive function than non-pet owners are not clear. It is possible that the responsibility of taking care of their pets, and other interactions with them, may have helped to maintain higher activity levels, leading to better executive function. Alternatively, however, it is possible that homebound older adults who had intact executive function were more likely to own pets. Without data on what these people were like before they owned pets, it is difficult to draw any conclusions. Regardless of known causal relationships, the finding that pet

owners had intact executive function is important because maintenance of executive function supports daily living activities and strongly predicts disability (Cahn-Weiner, Boyle and Malloy 2002; Royall et al. 2005; Johnson, Lui and Yaffe 2007).

A variety of neuroprotective factors are recommended to delay neurodegeneration and associated cognitive deficits in older adults (Mahendra, Thakur and Akash 2012), one of which may involve environmental enrichment by owning, taking care of, and being attached to companion animals. For example, environmental enrichment, with active social, mental and physical lifestyle, have improved stress reactivity and reversed physiological aging of the brain in animal models. Rodents who lived in complex housing (sensory, motor, and social stimulation) demonstrated improved ability and adaptive behaviors to cope with stress (Zambrana et al. 2007), and increased neurogenesis, synaptic density, and neurotrophic factors (Mora, Segovia and Del Arco 2007). Companion animals may similarly enrich homebound older adults' environments by providing active social, mental, and physical stimulation that enhances executive function.

Depression scores did not differ between pet owners and non-pet owners in our study. In a large scale survey (n = 2,551) conducted in Australia, however, Parslow et al. (2005) found that community-living older adult pet owners had significantly more depressive symptoms than non-pet owners. Although functional status was not reported in their study, approximately 30–40% of their participants were employed in the labor force, whereas homebound older adults have limited functional status and are generally unemployed, making findings of their study difficult to generalize to the homebound older adult. On the contrary, Crowley-Robinson, Fenwick and Blackshaw (1996) reported significant decreases over time in depression among older adult nursing-home residents who had a resident dog present for 15 months. And Le Roux and Kemp (2009) reported significant improvements in depression over time among physically disabled, long-term-care residents who interacted with a therapy dog once a week for 6 weeks. Given inconsistent human–animal interactions among various older adult populations and mixed findings, as well as our non-significant findings, additional research is needed to clarify the role of pet ownership on depression in the older adult.

Although there were no statistically significant differences in salivary CRP, there was a trend indicating that pet owners had lower levels than non-pet owners, and there was large inter-individual variability. In prior studies evaluating other immune responses (salivary IgA) to human–animal interactions, results were mixed. Charnetski, Riggers and Brennan (2004) reported significant improvements in salivary IgA levels among adults exposed to a brief visit with a dog; however, others have failed to replicate these findings (Barker et al. 2005; Krause-Parello et al. 2012). Large inter-individual variation in inflammatory and immune markers, as well as differences in study designs and settings, may have contributed to the mixed results. Larger sample sizes are needed in future research to help clarify if pets affect inflammatory responses in people.

Attachment to Pets

Participants with higher pet attachment scores showed higher executive function in our study, but the reason for this is not clear. Prior research indicates that administration of oxytocin improves neurogenesis (Jafarzadeh et al. 2014), even under stressful conditions (Leuner, Caponiti and Gould 2012) in animal models, and improves social memory in humans (Striepens et al. 2011). Thus, it is possible that attachment to pets increases oxytocin release, which may contribute to improved executive function. In a crossover design, Miller et al. (2009) measured

oxytocin in working men and women who were "well bonded" to their dogs. Participants either interacted with their companion dogs or read quietly after being separated from their pets while at work all day. An increase in oxytocin was found among women, but not in men, who interacted with their dogs, compared with the quiet-reading condition. Handlin et al. (2011) also found that women who interacted with their companion dogs showed a significant increase in oxytocin levels, compared with a control group (women who did not own or interact with a dog). Further research is needed to test the relationships between attachment to pets, oxytocin, gender, and health outcomes, using larger samples and longitudinal designs.

Limitations and Future Recommendations

This study had several limitations. A cross-sectional approach does not allow testing for a causal relationship. Therefore, it is unknown whether pet owners acquired a companion animal because they had intact executive function or if pet ownership helped preserved executive function. Biomarker assessment was limited to salivary CRP, which is a non-specific indicator of systemic inflammation. Although not measured in our study, oxytocin is another potential hormone related to pet attachment and executive function outcomes. Non-invasive measures of oxytocin would make using this more feasible in research.

Another limitation was the use of a single-item measure of pet attachment. This approach was used to reduce the burden on participants, but using a reliable and validated scale might have been a better choice. However, it is questionable how much variability could have been detected if a different instrument was used. We found a ceiling effect in our study, with the majority of owners marking the highest level of pet attachment.

Pet owners and non-pet owners did not differ significantly in terms of marital status, but social support from humans was not measured. If social support was different in the two groups, this may have influenced our findings.

Participants in our study were economically disadvantaged, primarily lived in low-income housing, and were largely Caucasians. Therefore, the findings of this study may not be generalizable to other homebound older adults.

Our study shows there are some associations between pet ownership, pet attachment, depression, systemic inflammation and executive function in homebound older adults. A companion animal may enhance executive function for these people, but it may also be the case that homebound older adults with intact executive function are more likely to own pets. Future studies with larger samples and a longitudinal design are needed to investigate the biobehavioral changes over time. Focusing on the biobehavioral aspects of pet ownership and attachment to pets will significantly contribute to our understanding of human–animal interactions.

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