

Leisure activities, caregiving demands and catecholamine levels in dementia caregivers

Elizabeth A. Chattillion^{ab}, Brent T. Mausbach^{b*}, Susan K. Roepke^{ab},
Roland von Känel^{bc}, Paul J. Mills^b, Joel E. Dimsdale^b, Matthew Allison^d,
Michael G. Ziegler^e, Thomas L. Patterson^b, Sonia Ancoli-Israel^b
and Igor Grant^b

^aJoint Doctoral Program in Clinical Psychology, San Diego State University/University of California, San Diego, CA, USA; ^bDepartment of Psychiatry, University of California, San Diego, CA, USA; ^cDepartment of General Internal Medicine, Inselspital, Bern University Hospital, and University of Bern, Switzerland; ^dDepartment of Family & Preventive Medicine, University of California San Diego, La Jolla, CA, USA; ^eDepartment of Medicine, University of California, San Diego, CA, USA

(Received 14 January 2011; final version received 30 October 2011)

This study examined whether satisfaction from leisure activities moderates the relationship between caregiving demands (i.e., hours per day spent caring for a spouse with dementia) and resting levels of the catecholamines norepinephrine (NE) and epinephrine (EPI). Spousal caregivers ($n = 107$; mean age = 73.95 ± 8.12 years) were assessed in home for plasma levels of NE and EPI, amount of care provided, and leisure satisfaction. Regression was used to determine whether leisure satisfaction moderated the relationship between hours providing care per day and catecholamine levels. A significant interaction was found between hours caregiving and leisure satisfaction for NE, but not for EPI. Post hoc regressions were conducted for both NE and EPI. At low leisure satisfaction, time spent caring for a spouse was positively associated with plasma NE ($\beta = 0.41$; $p = 0.005$) and EPI ($\beta = 0.44$; $p = 0.003$). In contrast, at high levels of satisfaction, time caregiving was not significantly associated with plasma NE ($\beta = -0.08$; $p = 0.57$) or EPI ($\beta = 0.23$; $p = 0.12$). These findings suggest that leisure satisfaction may protect caregivers from increases in catecholamines, which have been implicated in cardiovascular risk. Further support for these findings may impact psychological treatments for distressed caregivers.

Keywords: leisure satisfaction; leisure activities; catecholamine; dementia caregiving; cardiovascular disease

Introduction

Caring for a spouse with Alzheimer's disease (AD) is a life stressor that has been shown to negatively impact the psychological and physical health of the caregiver (Schulz, O'Brien, Bookwala, & Fleissner, 1995). For example, the chronic stress associated with providing care to a loved one with dementia increases caregivers' risk

*Corresponding author. Email: bmausbach@ucsd.edu

for psychiatric problems such as depression and anxiety (Mahoney, Regan, Katona, & Livingston, 2005). Additionally, caregivers with a high level of demand who experience mental or emotional strain are at increased risk for mortality as compared to noncaregivers (Schulz & Beach, 1999), which may be a result of the detrimental effects of caregiving stress on cardiovascular health (Lee, Colditz, Berkman, & Kawachi, 2003; Mausbach, Patterson, Rabinowitz, Grant, & Schulz, 2007; Shaw et al., 1999). Indeed, caregiving has been associated with an increased risk for both hypertension (Shaw et al., 1999) and cardiovascular disease (CVD; Lee et al., 2003; Mausbach et al., 2007; Schulz et al., 1995). Shaw et al. (1999) found that AD caregivers experienced a 67% increase in risk for hypertension as compared to noncaregiving controls over a three-year period. Lee and colleagues (2003) found that caring for a disabled spouse for more than 9 hours per week was associated with an increased risk of coronary heart disease (CHD) in women, even after controlling for various CHD risk factors. Mausbach et al. (2007) found that greater distress in dementia caregivers was associated with reduced time to developing CVD.

The exact mechanisms by which the demands placed on dementia caregivers result in impaired cardiovascular health remain unclear. While the translation of stress or emotional strain to impaired cardiovascular health is likely complex, emerging research suggests that increased sympathetic nervous system (SNS) arousal and the resultant increase in circulating catecholamines may be involved in the early stages of this process (Esler, 2010; Grant, 1999; Vitaliano, Zhang, & Scanlan, 2003). In this regard, it is well established that acute stress is associated with increased SNS activation, causing the release of various stress hormones, including catecholamines (Bhattacharyya & Steptoe, 2007; Black & Garbutt, 2002; McEwen, 2003). The release of catecholamines following psychological stressors results in physiological changes, such as haemostatic and inflammatory responses, that may increase the risk of atherothrombotic events (Bhattacharyya & Steptoe, 2007). For example, von Känel, Mills, Ziegler and Dimsdale (2002) found that an acute psychological stressor task elicited a significant increase in norepinephrine (NE) and the prothrombotic marker thrombin–antithrombin III (TAT) complex in a community sample of healthy adults, and that the increase in NE accounted for 39% of the variance in the increase in TAT. Similarly, Wirtz et al. (2006) found that increased NE release independently predicted an increase in D-dimer in response to an acute stressor task in healthy adult men. Importantly, frequent and excessive NE and epinephrine (EPI) surge may lead to physiological changes such as increased heart rate and blood pressure, which can accelerate the development of atherosclerosis (Grant et al., 2002; Lovallo & Thomas, 2000). As such, dementia caregivers who experience sustained increases in catecholamine levels due to prolonged stress related to their caregiving duties may be particularly vulnerable to these physiological changes resulting in poorer cardiovascular health (Grant, 1999; Vitaliano et al., 2003).

Indeed, elevated catecholamine levels have been observed in caregivers under high stress and high caregiving demand. Mills and colleagues (1997) found that AD caregivers who reported high stress had elevated plasma NE levels as compared to both nonstressed AD caregivers and noncaregiving controls. Vulnerable AD caregivers, defined as vulnerable based on the amount of care required by the patient relative to the amount of respite the caregiver received, exhibited 44% higher resting levels of plasma EPI as compared to nonvulnerable caregivers (Mills, Yu, Ziegler, Patterson, & Grant, 1999). An in-home respite intervention for these caregivers under high demand has been associated with a decrease in plasma

EPI after 1 month (Grant et al., 2003). Additionally, Mausbach et al. (2005) demonstrated that caregiver distress may impact catecholamine reactivity as well, finding that higher levels of depressive symptoms were associated with greater NE response to an acute stressor. These findings suggest that elevated levels of circulating catecholamines (NE and EPI) may occur as a result of high caregiving demands and related distress, which in turn may be a mechanism by which caregiving stressors lead to impaired cardiovascular health in dementia caregivers.

Despite the evidence indicating that caregiving is associated with negative cardiovascular outcomes, not all caregivers will manifest these negative health outcomes (Brown et al., 2009; Fredman, Cauley, Hochberg, Ensrud, & Doros, 2010). This suggests a need to identify protective factors that may attenuate the negative impact of caregiving on cardiovascular health. Engagement in leisure activities may be one such factor moderating the effect of caregiving on negative health outcomes. Although daily stressful experiences associated with increased caregiving demands may increase sympathetic activity and eventually increase risk for CVD, the presence of everyday 'uplifts', or positive experiences, may mitigate the impact of these negative daily events. Daily experiences may be conceptualized as being on a weighted scale, where a greater frequency of negative as compared to positive experiences produces imbalance. This imbalance may result in the negative psychological and physiological outcomes observed in many caregivers. Indeed, caregivers are known to experience high levels of daily stressors concomitant to low levels of positive experiences (Mausbach, Patterson, & Grant, 2008; Ory, Hoffman, Yee, Tennstedt, & Schulz, 1999). However, counteracting negative experiences with positive ones may pull the scale back into balance, thereby attenuating the detrimental impact of increased catecholamines related to stressful events on caregiver health.

Research on the role of leisure in positive outcomes supports the hypothesis that pleasant activities, as opposed to simply engaging in activities, play a role in improving physiological outcomes. For example, recent research in noncaregiving adults demonstrated that more frequent engagement in enjoyable leisure activities is associated with increased physical well-being, including lower blood pressure and lower total cortisol (Pressman et al., 2009). Additionally, the presence of positive emotions, which have been positively associated with both frequency of engagement in pleasant activities and satisfaction obtained from leisure activities in AD caregivers (Mausbach, Coon, Patterson, & Grant, 2008), has been associated with lower blood pressure reactivity (Ong & Allaire, 2005).

In the present study, we examined whether more frequent engagement in satisfying leisure activities mitigated the relations between increased caregiving demands and the physiological outcome of resting levels of catecholamines. The primary indicator of caregiving demands in this analysis was the number of hours per day that a caregiver spent providing care to their spouse. The amount of time spent caring for a spouse with AD represents the demand placed on a caregiver's time and resources and is also an indicator of caregivers' opportunity to experience stressful situations (e.g., greater frequency of stressful negative experiences such as disruptive behaviour by their spouse, more severe dementia and memory problems, and greater need for physical care). Furthermore, the number hours of care provided per day has indeed been associated with various physiologic outcomes in caregivers (Lee et al., 2003; Mills et al., 1999, 2004). The present study examined the interaction of satisfaction from leisure activities and the number of hours spent providing care per

day on resting levels of NE and EPI in a sample of 107 spousal AD caregivers. It was hypothesized that at low levels of leisure satisfaction, the number of hours providing care to a spouse per day would be significantly associated with resting levels of both NE and EPI but not at high levels of leisure satisfaction.

Method

Participants

Participants were spousal AD caregivers recruited from 2007 through 2009 to participate in the University of California, San Diego (UCSD) Caregiver Study. Participants were recruited through referrals from the UCSD Alzheimer's Disease Research Center, community support groups, health fairs and local senior centres. All participants provided written informed consent prior to enrolment and the study protocol was approved by the UCSD Institutional Review Board. All participants provided in-home care to a spouse with AD, were at least 55 years of age and were free of serious medical illness (e.g., cancer). Participants were excluded if they had extreme hypertension (blood pressure exceeding 200/120 mm Hg). Participants were also excluded if they were taking anticoagulant medications, because of interactions between these medications and variables collected as part of the UCSD Caregiver Study. Participants were asked to report all medications they were taking, and use of antihypertensive, antidepressants or anticoagulant medication was noted, as these medications may affect variables collected in the UCSD Caregiver Study.

Of 114 caregivers recruited, 7 caregivers completed the psychosocial assessment but did not complete a blood draw (described below), thus, 107 caregivers were included in the present analysis. A subset of the 107 caregivers used in the present analysis was later also recruited to participate in the UCSD Pleasant Events Project, which was designed to assess the role of pleasant events on various caregiver outcomes.

Procedures

All assessments were conducted in the caregivers' homes. A trained research assistant administered a structured psychosocial interview to assess each participant's general physical and psychological health, the dementia severity of the spouse and the degree of assistance provided by the caregiver. Demographic and descriptive information were obtained including participant age, gender, number of hours per day the caregiver currently spends caring for their spouse with AD and use of medications, including antihypertensive drugs. Following the psychosocial assessment, a research nurse inserted an indwelling venous catheter into a participant's forearm, while resting in a supine position. After catheter insertion, the participant was asked to rest for a period of 5 minutes, while keeping the hand level with the heart to control for hydrostatic differences. Then, two blood pressure measurements were obtained with the participant resting for 10 minutes in-between measurements. Thus, a total of 15 minutes after catheter insertion, a blood sample was drawn, discarding the first 2 mL. Samples were placed on crushed ice and then processed for storage in a -80°C freezer until assayed. All blood samples were collected in the morning, between 8:00 and 10:00 a.m.

Measures

Leisure satisfaction

Caregivers' engagement in leisure activities was assessed using a modified version of the Pleasant Events Schedule-Alzheimer's Disease (PES-AD; Logsdon & Teri, 1997). Participants rated the frequency of participation in 20 pleasant leisure activities over the past month. Response choices were 0 = 'not at all', 1 = 'a few times (1–6 times)' and 2 = 'often (7 or more times)'. Participants were also asked to rate how much they enjoyed each activity. Response choices were 0 = 'not at all', 1 = 'somewhat' and 2 = 'a great deal'. The vast majority of items in the PES-AD address nonphysical leisure activities (e.g., 'watching TV', 'reading or listening to stories', 'shopping or buying things', 'going for a ride in the car' and 'having coffee, tea, etc. with friends'), with only one item of 20 assessing exercise activities (e.g., 'exercising (walking, dancing, etc.)'). The effect of positive activities was assessed by examining not merely the frequency of caregivers' engagement in leisure activities, but the amount of satisfaction experienced by the caregiver. A cross-product of the frequency and enjoyment scores was computed for each item (range = 0–4 for each item). The total leisure satisfaction score (range = 0–80) was computed as the sum of these cross-products. For the purposes of this study, we defined leisure satisfaction as more frequent engagement in satisfying or enjoyable leisure activities.

Although the PES-AD was developed as a scale to assess pleasant events in patients with AD, the instructions were modified to instruct caregivers to report their own activities during the past month as well as their own level of enjoyment of each activity. Additionally, although the scale was designed for patients with AD, the leisure activities listed in the scale are not exclusively or differentially enjoyed by persons with AD (e.g., 'having meals with friends or family'). Because not all activities on the scale are enjoyed by all caregivers, we used the leisure satisfaction summary score which multiplied the frequency of a given activity by the caregiver's rating of enjoyability. Therefore, activities that were not enjoyed by the caregiver (i.e., not considered leisure activities) were given an enjoyability score of 0, and a cross-product score of 0, thus, any activities that were not enjoyed by the caregiver did not contribute to the overall 'leisure satisfaction' score. Additionally, previous research with AD caregivers has used the PES-AD to demonstrate associations between engagement in leisure activities and positive affect (Mausbach, Coon, et al., 2008), depressive symptoms, role overload, positive and negative coping variables and sleep quality (Mausbach et al., 2011). Internal consistency in this sample of caregivers was good, with a Cronbach's alpha for the leisure satisfaction cross-product score of 0.80.

Dementia severity of the AD patient

The Clinical Dementia Rating (CDR) scale provides a global assessment of dementia severity (Morris, 1993). The scale required caregivers to report on their family member's level of functioning in six behavioural and cognitive domains: memory, orientation, judgment and problem solving, community affairs, home and hobbies, and personal care. Scores on these six domains are used to create an overall score of dementia severity ranging from 0–3, with higher scores indicating greater dementia severity. Scoring was determined using the online calculator from the Washington

University Alzheimer's Disease Research Center (<http://www.biostat.wustl.edu/~adrc/cdrpgm/index.html>). The CDR was administered by trained research personnel who rated the care recipient's functioning in the six domains on the basis of information reported by the caregiver. Interactions with the care recipient were not regularly conducted as part of the CDR administration because caregivers often used day care or other services so that the spouse with dementia was not present for the interview.

Caregiver level of physical activity

Caregivers' level of physical activity was assessed using the Rapid Assessment of Physical Activity (RAPA) questionnaire, designed for use with older adults (≥ 50 years of age; Topolski et al., 2006). The RAPA was developed based on the Centers for Disease Control and Prevention (CDC) guidelines for physical activity, which recommends 30 minutes or more of moderate physical activity on most days of the week. Participants responded to nine 'yes' or 'no' items assessing the frequency and duration of their engagement in light, moderate and vigorous exercise (the RAPA provided descriptions and examples of each of these three levels of physical activity). Based on participants' responses to these nine items, a dichotomous variable was created for this analysis indicating whether the participant met the CDC guidelines for weekly physical activity (i.e., 0 = participant did not meet CDC guidelines; 1 = participant met CDC guidelines).

Plasma catecholamine levels

The NE and EPI levels were assessed using a catechol-O-methyltransferase (COMT) radioenzymatic assay that extracts the catecholamines from 1 mL of plasma and removes Ca^{2+} and other components that inhibit the radioenzymatic assay (Kennedy & Ziegler, 1990). This technique provides sufficient sensitivity to measure small changes in basal EPI levels that might not be detected by most other catecholamine assays.

Body Mass Index

The Body Mass Index (BMI) was computed as the ratio between weight in kilograms and height in square meters. Participant height and weight was self-reported during the psychosocial assessment.

Statistical analysis

Before conducting statistical analyses, the distributions of the two outcome variables were examined for normality. Resting NE and EPI were both found to be positively skewed and both variables were normalized using a square root transformation. The regression approach described by Holmbeck (1997) was used to test the moderating effect of satisfaction from leisure activities on the relationship between hours providing care per day and resting levels of both NE and EPI. This approach recommends that the main effects for the predictor (i.e., hours providing care per day) and the moderator (i.e., leisure satisfaction), as well as any covariates, are entered into the regression model first, followed by the interaction between the

predictor and the moderator. The overall regression analyses to predict (square root) NE and EPI were entered in two steps. In Step 1 age, gender, BMI, CDR total score (i.e., dementia severity of the AD patient), antihypertensive medication use and level of physical activity (i.e., whether caregiver meets the CDC guidelines for physical activity) were entered as covariates, along with the two main effects of hours providing care per day and leisure satisfaction. The interaction term of hours providing care per day and leisure satisfaction was entered in Step 2 of the regression. All predictor variables entered into the regression model were centred in order to reduce potential problems that may result from multicollinearity (J. Cohen, P. Cohen, West, & Aiken, 2003). Linear variables were centred at their means. Gender, antihypertensive use and physical activity were centred as +0.5 (women; using medication; meets CDC guidelines for physical activity) and -0.5 (men; not using medication; does not meet CDC guidelines). Holmbeck's approach (1997, 2002) to testing moderation effects also describes procedures for post hoc probing of potential moderator effects, which can be conducted by running separate regression analyses for high (+1 standard deviation) and low (-1 standard deviation) levels of leisure satisfaction and plotting simple slopes of the regression lines.

Results

Participants characteristics

Detailed demographic characteristics of the sample of 107 caregivers in the analysis (mean age = 73.95 ± 8.12 years) are presented in Table 1. Most participants were female, Caucasian and had at least some college education. The mean level of impairment of the AD patient was mild to moderate and caregivers spent an average of 7.61 (± 5.91) hours per day caring for their spouse. The mean leisure satisfaction score for caregivers was 55.70 (± 12.61). Hours of care provided per day had a negligible correlation with leisure satisfaction scores ($r = -0.05$). Resting levels of NE and EPI were moderately and positively correlated ($r = 0.45$, $p < .001$).

The item in the PES-AD that was endorsed as most enjoyable for caregivers was 'being with family (other than your spouse)'. A total of 97.89% of caregivers who reported that they had engaged in this activity within the past month endorsed that they enjoyed the activity 'a great deal'. The other items that most caregivers rated as highly enjoyable were 'having meals with friends or family' (94.90% of caregivers who engaged in this activity reported enjoying it a great deal), 'laughing' (94.29%), 'listening to the sounds of nature' (93.88%), 'going on outings' (93.90%), 'being outside' (92.52%) and 'reading or listening to stories' (92.16%). The activities enjoyed least by caregivers were 'helping around the house' (38.32% of caregivers who engaged in this activity reported enjoying it a great deal), 'shopping' (57.01%), 'going for a ride in the car' (63.11%) and 'grooming' (65.69%).

Caregivers who did not provide a blood sample and were excluded from the present analysis did not differ from the caregivers in the analysis on important characteristics such as age, $t(112) = -1.54$, $p = 0.13$; BMI, $t(112) = -0.76$, $p = 0.45$; leisure satisfaction, $t(112) = -0.90$, $p = 0.37$; or hours providing care per day, $t(112) = 0.364$, $p = 0.72$. All of the participants excluded were female. The CDR scores of the care recipient were higher in the group of caregivers excluded from the analysis, $t(112) = 2.09$, $p = 0.04$.

Table 1. Participant characteristics.

Variable	<i>n</i> = 107
Age, <i>M</i> (SD), years	73.95 (8.12)
Gender, <i>n</i> (%)	
Male	34 (31.78)
Female	73 (68.22)
Race, <i>n</i> (%)	
Caucasian	101 (94.39)
Other	5 (4.67)
Education, <i>n</i> (%)	
Less than high school	2 (1.87)
High school	19 (17.76)
Some college	37 (34.58)
College graduate	49 (45.79)
Monthly income, median, \$	4500
Antihypertensive drug use, <i>n</i> (%)	
Present	64 (59.81)
Absent	43 (40.19)
Physical activity, <i>n</i> (%)	
Meets CDC guidelines	36 (33.64)
Does not meet CDC guidelines	71 (66.36)
Resting NE, <i>M</i> (SD), pg/mL	477.71 (211.11)
Resting EPI, <i>M</i> (SD), pg/mL	32.32 (15.03)
BMI, <i>M</i> (SD)	26.62 (4.80)
Patient CDR total score, <i>M</i> (SD)	1.62 (0.64)
Leisure satisfaction, <i>M</i> (SD)	55.70 (12.61)
Hours providing care/day, <i>M</i> (SD)	7.61 (5.91)

Note: *M*=mean; SD=standard deviation; CDC=Centers for Disease Control and Prevention; NE=norepinephrine; EPI=epinephrine; BMI=Body Mass Index.

Leisure satisfaction moderator analysis for NE

Results of the regression predicting resting NE levels are presented in Table 2. No significant main effects were observed for age, gender, BMI, CDR score, antihypertensive use or physical activity. Main effects for hours providing care per day and leisure satisfaction were also not significant. However, there was a significant interaction between hours providing care per day and leisure satisfaction, $t(97) = -2.36$, $p = 0.02$, indicating that leisure satisfaction may be a potential moderator of the relationship between hours providing care per day and resting NE level. Overall, the regression model accounted for 19.8% of the variance in resting NE levels.

In accordance with Holmbeck's (2002) approach to moderation analysis, post hoc analyses were conducted to probe the significant interaction between leisure satisfaction and hours providing care per day, as described above. The regression analysis for low leisure satisfaction indicated that the number of hours providing care per day was significantly associated with resting NE levels, $\beta = 0.41$; $t(97) = 2.89$, $p = 0.005$. However, in the regression analysis for high leisure satisfaction the number of hours providing care per day was not significantly associated with resting NE levels, $\beta = -0.08$; $t(97) = -0.57$, $p = 0.57$. Regression lines

Table 2. Regression model predicting (square root transformed) NE.

	<i>B</i>	SE	β	<i>t</i>	<i>p</i>
Age	0.06	0.06	0.10	0.97	0.33
Gender	1.30	0.96	0.13	1.36	0.18
BMI	-0.03	0.11	-0.03	-0.27	0.79
CDR score	1.39	0.78	0.19	1.79	0.08
Antihypertensive use	-0.11	0.99	-0.01	-0.11	0.91
Physical activity	0.86	0.99	0.09	0.87	0.39
Hours providing care per day	0.13	0.08	0.16	1.69	0.09
Leisure satisfaction	-0.06	0.04	-0.17	-1.63	0.11
Hours providing care \times leisure satisfaction	-0.02	0.01	-0.23	-2.36	0.02

Note: $n = 107$; $df = 9, 97$; $R^2 = 0.198$; adjusted $R^2 = 0.124$; NE = norepinephrine; CDR = Clinical Dementia Rating.

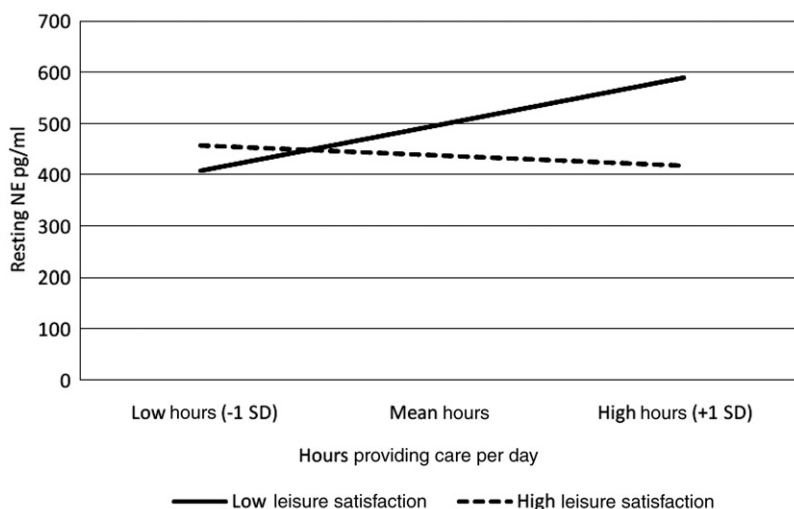


Figure 1. Post hoc probing of significant interaction between hours providing care per day and norepinephrine (NE; $\beta = -0.23$, $p = 0.02$). Regression lines for the relationship between hours providing care per day to a spouse with Alzheimer's disease (AD) and resting levels of NE for both high and low levels of leisure satisfaction; SD = standard deviation.

for raw values of resting NE levels for high and low leisure satisfaction are presented in Figure 1.

Leisure satisfaction moderator analysis for EPI

The same procedure for examining potential moderation effects of leisure satisfaction was conducted with respect to resting EPI levels as well. Results of the regression model predicting EPI levels are presented in Table 3. A significant main effect was found for BMI, $\beta = -0.29$; $t(97) = -2.59$, $p = 0.01$, and hours providing care per day, $\beta = 0.34$; $t(97) = 3.39$, $p = 0.001$. The interaction between hours providing care per day and leisure satisfaction was not significant in the regression

Table 3. Regression model predicting (square root transformed) EPI.

	<i>B</i>	SE	β	<i>t</i>	<i>p</i>
Age	-0.02	0.02	-0.10	-1.04	0.30
Gender	-0.24	0.26	-0.09	-0.92	0.36
BMI	-0.08	0.03	-0.29	-2.59	0.01
CDR score	-0.33	0.21	-0.16	-1.55	0.13
Antihypertensive use	0.43	0.27	0.17	1.58	0.12
Physical activity	-0.12	0.27	-0.05	-0.46	0.65
Hours providing care per day	0.07	0.02	0.34	3.39	0.001
Leisure satisfaction	-0.02	0.01	-0.16	-1.57	0.12
Hours providing care \times leisure satisfaction	-0.002	0.002	-0.10	-1.03	0.31

Note: $n = 107$; $df = 9, 97$; $R^2 = 0.161$; adjusted $R^2 = 0.083$; EPI = epinephrine; CDR = Clinical Dementia Rating.

model predicting resting EPI levels, $t(97) = -1.03$, $p = 0.31$. Overall, the regression model accounted for 16.1% of the variance in resting EPI levels.

Although the interaction in the initial regression analysis indicated that the relationship between hours providing care and resting EPI levels was not significantly different for high leisure satisfaction versus low leisure satisfaction, exploratory post hoc analyses were still conducted in order to determine whether the relationship between hours providing care and resting EPI levels is significant for either the low leisure satisfaction or the high leisure satisfaction conditions. These post hoc analyses were exploratory in nature and may generate hypotheses for future studies. Separate regression analyses were conducted for high and low levels of leisure satisfaction and simple slopes for the high and low leisure satisfaction conditions were computed.

The regression analysis for low leisure satisfaction indicated that the number of hours providing care per day was significantly associated with resting EPI levels, $\beta = 0.44$; $t(97) = 3.08$, $p = 0.003$. In contrast, the regression analysis for high leisure satisfaction indicated that the number of hours providing care per day was not significantly associated with resting EPI levels, $\beta = 0.23$; $t(97) = 1.56$, $p = 0.12$. Regression lines for raw values of resting EPI levels for high and low leisure satisfaction are presented in Figure 2.

Additionally, the same moderator analyses were conducted with frequency of engagement in activities as the moderator, rather than leisure satisfaction, to disentangle the effects of leisure satisfaction from mere engagement in activities. There was no significant interaction between frequency of engagement in activities and hours providing care per day on NE, $\beta = -0.13$; $t(97) = -1.33$, $p = 0.19$, or EPI, $\beta = 0.013$; $t(97) = 0.136$, $p = 0.89$.

Discussion

The results of this study demonstrated a significant moderating effect of leisure satisfaction on the relationship between spousal Alzheimer caregivers' level of caregiving demand and resting level of NE. Specifically, caregivers who experienced high leisure satisfaction in the past month did not show a significant association between the number of hours providing care to a spouse per day and resting levels of

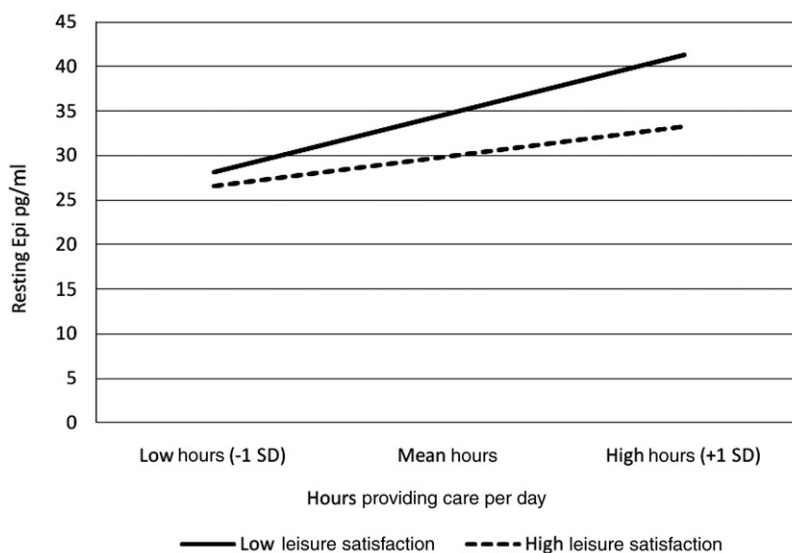


Figure 2. Post hoc probing of nonsignificant interaction between hours providing care per day and epinephrine (EPI; $\beta = -0.10$, $p = 0.31$). Regression lines for the relationship between hours providing care per day to a spouse with Alzheimer's disease (AD) and resting levels of EPI for both high and low levels of leisure satisfaction; SD = standard deviation.

NE. Caregivers with low leisure satisfaction demonstrated an association between greater time spent caring for a spouse per day and increased resting NE levels, which may be associated with increased cardiovascular risk (Bhattacharyya & Steptoe, 2007; Lovallo & Thomas, 2000). These results suggest that caregivers with high leisure satisfaction were protected from negative physiological consequences of caregiving demands, despite providing similar levels of care as caregivers reporting low leisure satisfaction. The current study therefore provides evidence for a possible buffering effect of leisure satisfaction on the relationship between caregiving demands and resting NE. Importantly, the frequency of engagement in activities did not moderate the relationship between caregiving demands and NE or EPI, suggesting that satisfaction with leisure activities was driving the buffering effect observed. These results expand upon previous research demonstrating an association between increased caregiving demands and caregiving stress and elevated catecholamine levels (Mills et al., 1997, 1999), by identifying specific circumstances under which this association may be less likely to occur (i.e., when leisure satisfaction is high). These findings suggest that the negative impact of caregiving on the cardiovascular health of the caregiver may be attenuated by caregivers' engagement in enjoyable leisure activities. The significant interaction between leisure satisfaction and amount of care provided on resting levels of NE is particularly important given the substantial role of sympathetic activation, and in particular NE, in the development of CVDs (Esler, 2010).

Our results indicated that the interaction between leisure satisfaction and amount of care provided was not significant with respect to resting EPI levels. The lack of significant interaction on EPI levels may stem from the fact that EPI is present at lower levels in the blood and some assays cannot detect low normal levels of EPI. Although the COMT radioenzymatic assay used in this analysis is more sensitive to

small changes in basal EPI levels that might not be detected by many other catecholamine assays (Kennedy & Ziegler, 1990), low EPI levels may increase assay variability and failure to find an interaction effect for EPI may be due to assay noise interfering with physiologic signal. Additionally, evidence suggests that EPI is released in response to acute stressors (Dimsdale & Moss, 1980), while NE, but not EPI, levels increase in response to chronic, low-level stressors (Konarska, Stewart, & McCarty, 1990). The daily hassles encountered when providing care to a spouse with AD likely constitute chronic, low-grade stressors. Additionally, older individuals display decreased EPI response to mental stress, while their NE response to mental stressors increases (Seals & Esler, 2000). Chronic and mental stressors that arise with increased caregiving demands may be associated with greater increases in NE than EPI in our sample. The relationship between caregiving demands and NE may be particularly influenced by engagement in satisfying leisure activities, which may provide a reprieve from daily stresses. However, the exploratory post hoc analyses showed a significant relationship between care provided and EPI levels for low but not high leisure satisfaction, suggesting that further investigations of the role of leisure satisfaction in moderating the influence of caregiving stress on plasma EPI may be warranted.

Although the results of this study require replication, the identification of behavioural factors that may buffer the negative effect of caregiving demands on cardiovascular health outcomes may have implications for the health and treatment of dementia caregivers. Behavioural activation interventions, which focus on increasing engagement in leisure activities, have been previously used successfully in caregiving populations to treat psychological problems such as depression (Coon, Thompson, Steffen, Sorocco, & Gallagher-Thompson, 2003; Gallagher-Thompson & Coon, 2007). Our results suggest that interventions aimed at increasing pleasurable leisure activities may also improve cardiovascular outcomes in caregivers by reducing NE levels. Interventions that focus on increasing leisure activities for the caregiver are particularly appealing, because it is more feasible for caregivers to change their own behaviour than to change the dementia-related behaviours of their spouse. Indeed, our results show that increasing levels of care provided have no substantive impact on catecholamine levels among caregivers who maintain exposure to positive leisure activities. The negligible correlation between amount of care provided per day with leisure satisfaction scores ($r = -0.05$) suggests that despite increasing levels of caregiving demands, some caregivers maintain adequate exposure to pleasant leisure activities. Additionally, because behavioural activation interventions do not require intensive training and can be delivered by lay therapists, they are likely cost-effective and more easily implemented into community settings than more complex skills-based and multicomponent interventions. Although the present study indicates that high levels of leisure satisfaction may prevent increases in catecholamine levels in dementia caregivers, future studies should examine whether interventions designed to increase leisure activities help reduce resting levels of catecholamines among caregivers under high demand.

Our study is not without limitations. It is important to note that the cross-sectional design of the study precludes drawing causal inferences. Our results indicate that increasing demands on the caregiver are not associated with increased NE levels when caregivers have high levels of leisure satisfaction, suggesting that increased leisure satisfaction may mitigate the associations between caregiving demands and SNS arousal. Although leisure satisfaction may influence the effect of caregiving

demands on NE, it is also possible that caregiving demands and NE levels may influence leisure satisfaction. Caregivers with fewer demands may have lower subjective stress and lower NE levels to begin with, and may be more able to appreciate and enjoy daily pleasant activities, while caregivers who have greater demands on their time and greater NE levels may be more stressed and less able to appreciate daily events that could be considered positive. The directionality of the effect cannot be determined from the cross-sectional data presented.

Additionally, due to power considerations limiting the number of covariates entered in the analysis, we did not control for factors such as caregiver resources (e.g., social support) and coping factors (e.g., self-efficacy), which may impact caregivers' response to the demands placed upon them by their caregiving duties and may impact the relationship between caregiving stressors and health outcome (Pearlin, Mullan, Semple, & Skaff, 1990). However, previous research suggests that increased engagement in pleasurable leisure activities is associated with increased use of positive coping strategies and reduced use of negative coping strategies (Mausbach et al., 2011). These results suggest that leisure satisfaction may be sufficient as a treatment target, given its association with improvements in these other resource factors. Nonetheless, future research might explicitly examine the interrelations among participant characteristics, resources, coping strategies and leisure satisfaction with respect to their influence on the physiological outcomes of increased caregiving demands. Although we did attempt to control for the dementia severity of the care recipient in our analyses, feasibility issues prevented exact adherence to CDR administration protocol (i.e., scoring was based only on interactions with caregivers without regular interaction with care recipients), which may have resulted in inaccurate dementia ratings.

Another limitation of the present study was that the measurement of leisure satisfaction may have been influenced by factors which were not measured, such as noncaregiving-related stressors or personality traits of the caregiver. Future studies investigating the impact of leisure satisfaction on caregiver outcomes should control for the influence of such variables. Several factors may also limit interpretation of the measures of resting catecholamine levels in the present study. It was not possible to control for the totality of relevant variables that may influence circulating catecholamine levels. For example, we did not obtain information about participants' dietary habits or caffeine consumption, nor were we able to control for the presence of all possible medical conditions or medications that may impact catecholamine levels in the blood. Our interpretation of the current findings would be strengthened by replication in similar caregiving samples controlling for these factors. Additionally, resting catecholamine levels were measured at only one time point, which may not be ideal given that plasma NE and EPI display diurnal variation (Linsell, Lightman, Mullen, Brown, & Causon, 1985; Prinz, Halter, Benedetti, & Raskind, 1979). However, all samples were obtained within a relatively small time window.

The present study examined the moderating effect of overall level of leisure satisfaction on the relationship between caregiving demands and catecholamine levels; however, this relationship may be differentially affected by various types of leisure activities. Additional research may seek to compare the moderating effect of satisfaction obtained from varying types of leisure activities, such as physical activities or activities involving social interaction. Although the results of this study may be applicable to dementia caregivers, it is unclear whether our findings

generalize to other types of caregivers or to noncaregiving populations under chronic stress. Furthermore, given that the present study was conducted with a predominantly Caucasian sample, these findings must be replicated in minority populations in order to determine whether the results are generalizable.

In summary, we found evidence that spousal Alzheimer caregivers with high levels of leisure satisfaction did not display an association between increased caregiving demand and higher resting levels of NE and EPI, although this association was observed in caregivers reporting low leisure satisfaction. These findings suggest that increased satisfaction from leisure activities (i.e., balancing stressful negative events with positive events) may protect caregivers under high demand from related increases in catecholamine levels, particularly NE, which has been implicated in increasing cardiovascular risk. If further research supports these findings, this would suggest that behavioural activation interventions for increasing leisure satisfaction in dementia caregivers may result in reduced catecholamine levels and, in turn, reduced risk for CVD. Support for these findings may encourage a new approach to the prevention and treatment of distress and negative health outcomes in dementia family caregivers that focuses on maintaining balance between positive and negative experiences in the caregiver's life.

Acknowledgements

Primary research support was provided via funding from the National Institute on Aging (NIA) through award R01 AG015301. Additional support was provided by the NIA through award R01 AG031090.

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