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Effects of Alzheimer caregiving on allostatic load

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Abstract

This study aimed to determine if Alzheimer caregivers have increased allostatic load compared to non-caregivers. Potential psychological moderators (mastery, depression, and role overload) of the relationship between caregiving status and allostatic load were also explored. Eighty-seven caregivers and 43 non-caregivers underwent biological assessment of allostatic load and psychological assessments. Caregivers had significantly higher allostatic load compared to non-caregivers ($p < .05$). Mastery, but not depression and overload, moderated the relationship between caregiving status and allostatic load. In conclusion, allostatic load may represent a link explaining how stress translates to downstream pathology, but more work is necessary to understand the role of psychological factors.

Keywords

allostatic load; Alzheimer's disease; caregiving; chronic stress; coping

Introduction

Over the past few decades, much attention has been focused on understanding the key mechanisms that might explain how chronic stress translates into downstream health outcomes. McEwen and Stellar (1993) published a seminal review in which they introduced allostatic load as their formulation characterizing the relationship between chronic stress and disease. They proposed that exposure to environmental stressors catalyzes a number of physiologically-adaptive processes meant to protect the body from harm. However, frequent and sustained exposure to such stressors may produce an insufficient or overreacting

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Conflicts of Interest

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allostatic response, resulting in cumulative “wear and tear” to the body. Therefore, allostatic load as a construct represents the cumulative damage that multiple physiologic systems have endured in the process of adapting to stressors, resulting in increased risk for disease.

In support of McEwen and Stellar’s formulation, Seeman and colleagues (1997) demonstrated in a community-based study of aging that their multi-system measure of allostatic load did indeed predict poorer cognitive and physical functioning, decline in cognitive and physical function over time, and incidence of cardiovascular disease (CVD). In their study, allostatic load was quantified as a composite score indicating “risk” on ten equally-weighted physiological indicators: systolic and diastolic blood pressure, waist-hip ratio, high-density lipoprotein (HDL) cholesterol, total glycosylated hemoglobin, total cholesterol-HDL ratio, dehydroepiandrosterone sulphate (DHEA-S), and urinary cortisol, norepinephrine, and epinephrine. Since the publication of this study, numerous investigations have adopted this quantification of allostatic load (Clark, Bond, & Hecker, 2007; Karlamangla, Singer, McEwen, Rowe, & Seeman, 2002; Maselko, Kubzansky, Kawachi, Seeman, & Berkman, 2007; Seeman, McEwen, Rowe, & Singer, 2001; Seeman, Singer, Ryff, Dienberg, & Levy-Storms, 2002; Singer & Ryff, 1999; M. Weinstein, Goldman, Hedley, Yu-Hsuan, & Seeman, 2003). However, the theoretical construct of allostatic load is still a preliminary attempt to conceptualize the cumulative cost of adaptation, and there have been several other approaches in operationalizing this construct. Therefore, Singer et al. (2004) specified that quantification of allostatic load should capture dysregulation of one or more biological systems, multiple pathways to disease, and cumulative cost of antecedent challenges, and should also act as an early indicator of downstream morbidity.

One growing population of chronically stressed individuals is spousal caregivers of patients diagnosed with Alzheimer’s disease. Research suggests that caregivers are at increased risk for psychiatric morbidity (Mahoney, Regan, Katona, & Livingston, 2005) and overall mortality (Schulz & Beach, 1999). Moreover, caregivers are at increased risk for CVD (Vitaliano, et al., 2002) and associated risk factors (Shaw, et al., 1999), and demonstrate stress-related cardiovascular (CV) impairment (Aschbacher, et al., 2006; Mausbach, Mills, et al., 2007; Mausbach, von Känel, et al., 2008; Mills, et al., 2004; von Känel, et al., 2005; von Känel, et al., 2006). Research has also demonstrated that caregivers experience dysregulation of diverse physiological systems, including immune (Kiecolt-Glaser, Dura, Speicher, Trask, & Glaser, 1991; Kiecolt-Glaser, Glaser, Gravenstein, Malarkey, & Sheridan, 1996) and metabolic (Vitaliano, et al., 2002) function. Therefore, it is plausible that this population would exhibit increased allostatic load compared to non-caregiving controls.

Previous literature suggests that psychosocial factors may play an important role in understanding how Alzheimer caregiving translates into increased risk for negative physical health outcomes (Mausbach, Patterson, et al., 2007; Pearlin, Mullan, Semple, & Skaff, 1990). For example, coping strategies are theoretically important factors that may moderate the relationship between environmental stress and disease. Therefore, it is reasonable to postulate that use of positive coping strategies might protect against negative physical outcomes associated with caregiving. Consistent with theory, previous research in Alzheimer caregivers has found that high personal mastery had a protective effect on global measures of psychological distress (Mausbach, et al., 2006), medical and depressive symptoms (Mausbach, Patterson, et al., 2007), fatigue (Roepke, et al., 2009), sympathetic activation to stress (Roepke, et al., 2008), and coagulation (Mausbach, von Känel, et al., 2008).

Conversely, those with depression and high levels of burden may be ill-equipped to handle stressors and may experience worsened physical outcomes. A large body of evidence suggests that those with major depressive disorder may be vulnerable to increased allostatic load (reviewed by McEwen (2003)). Past research also suggests that depression may differentially impact physiological reactivity to stress in caregivers compared to non-caregiving controls, such that depression has been associated with prolonged sympathetic activation and increased platelet response in caregivers, but not in non-caregivers (Aschbacher, et al., 2008). Several studies have also found an association between increased measures of burden and poorer self-rated health and increased somatic symptoms (Elliot, Burgio, & DeCoster, 2010; Gräsel, 1995; Schulz, O'Brien, Bookwala, & Fleissner, 1995). Furthermore, von Känel and colleagues (2006) found that burden affected the relationship between caregiving status and the hemostasis marker, d-dimer; however the exact nature of the role of burden in this relationship was unclear. It is possible that these findings may be explained by the fact that those who are depressed and/or burdened may also lack adequate resources to engage in positive coping. Indeed, previous work has found that depressive symptoms are associated with decreased use of positive coping strategies (Burns, Shaw, & Croker, 1987), increased use of avoidance coping (Doering, et al., 2004), and increased physiological reactivity to stressors (Mausbach, et al., 2005). Likewise, caregiver burden has been associated with decreased confidence in problem solving, decreased use of spiritual and extended family support resources, and decreased ability to reframe a problem's manageability, as well as increased avoidance coping (Pratt, Schmall, Wright, & Cleland, 1985).

Given the accumulating evidence that Alzheimer caregivers are at increased risk for stress-related impairment in multiple physiological systems, our primary hypothesis was that caregivers would have elevated allostatic load compared to demographically similar non-caregiving peers. Our secondary hypothesis was that caregiver allostatic load would be worsened by depressive symptoms and burden (role overload) and lessened in those exhibiting higher mastery.

Methods

Participants

Participants included 87 spousal caregivers of patients with Alzheimer's disease (CG) and 43 married, non-caregiving controls (NC). Both CG and NC were enrolled in a 5-year longitudinal study examining the psychobiological effects of caregiving stress in older adults. Data for the current study were from the baseline assessment. Participants were recruited through a variety of community programs including referrals from the University of California, San Diego (UCSD) Alzheimer's Disease Research Center, local senior centers, support groups, health fairs, senior networking meetings, as well as media advertisements. Prior to enrollment, each participant provided written informed consent for participation as approved by the UCSD Institutional Review Board.

Eligible participants were required to be at least 55 years of age, currently living with their spouse, and free of serious medical illness (e.g. cancer). Participants taking anticoagulant medications were excluded due to their interaction with other variables collected as part of the larger study.

Procedures

Participants completed psychological and biological assessments in their own homes administered by trained personnel (registered nurse and research assistant). Psychological and biological assessments were conducted in separate visits within 1 week of each other

and all biological assessments were conducted between 8AM and 10AM in order to reduce variability due to diurnal fluctuations. For the psychological assessment, participants completed a semi-structured interview including measures assessing the general state of physical and psychological health, dementia severity of the spouse, and other psychosocial factors related to stress and coping. For the biological assessment, participants had an indwelling venous catheter inserted into the forearm while resting in a supine position. After catheter insertion, participants rested for a period of 5 minutes while keeping the hand level with the heart to control for hydrostatic differences. After this time, the first blood pressure measurement was taken. The participant then rested for an additional 10 minutes after which the second blood pressure measurement was recorded. The blood draw was then obtained, while discarding the first 2 ml. Samples were placed on crushed ice and then processed for storage in a -80° freezer until assayed. Blood collection was followed by the final blood pressure recording.

Psychosocial Measures

Mastery—Participants completed the 7-item Personal Mastery scale (Pearlin & Schooler, 1978) assessing one's sense of mastery. Participants rated their agreement on a 4-point scale with statements such as, "what happens to me in the future mostly depends on me." Ratings were summed to obtain an overall mastery score (7=lowest mastery; 28=highest mastery). In our sample of 130 participants, the Personal Mastery scale demonstrated strong internal consistency and had a Cronbach's alpha coefficient of .85.

Depressive Symptoms—The short form of the Center for Epidemiologic Studies Depression Scale (CESD-10) (Andresen, Malmgren, Carter, & Patrick, 1994), was used in order to assess participant depressive symptoms. This 10-item instrument has established reliability and validity in older adults (Andresen, et al., 1994). Participants rated the extent to which they identified with statements such as, "I felt depressed" and "I felt lonely," on a 4-point scale (0 = rarely or none of the time (< 1 day); 3 = most of almost all the time (5–7 days)). In our sample, the CESD-10 had an alpha coefficient of .83.

Burden—The Role Overload scale (Pearlin, et al., 1990) was used to assess participants perceived level of burden. Participants were instructed to rate their agreement with 4 statements such as, "I have more things to do than I can handle." Ratings were made on a 4-point scale (0 = "not at all"; 3 = "completely"). Items were summed in order to derive a total overload score. Pearlin and colleagues demonstrated that The Role Overload scale had strong internal consistency in a sample of 555 dementia caregivers (alpha = .80). In our sample of participants, the Role Overload scale had an alpha coefficient of .84.

Biological Measures

Blood Pressure—Systolic and diastolic blood pressure was taken using a noninvasive blood pressure machine (Microlife Blood Pressure Monitor). Three different resting blood pressure measurements were averaged to calculate an overall composite systolic and diastolic blood pressure score.

Body Mass Index (BMI)—BMI was calculated as the ratio between weight in kilograms and height in square meters.

Plasma Catecholamines—Norepinephrine and epinephrine levels were extracted using a catechol-O-methyltransferase (COMT) radioenzymatic assay that removed the catecholamines from 1 ml of plasma and concentrated them into 0.1 ml of dilute acid. This process is 10 times as sensitive as basic catecholamine assays routinely conducted, has an

81% efficiency rate, and removes Ca²⁺ and other components that inhibit the COMT assay (Kennedy & Ziegler, 1990).

Total and HDL Cholesterol—Cholesterol levels were assessed in serum by the Beckman-Coulter LX20 PRO.

Allostatic Load Index

Allostatic load was quantified using seven of the ten measures employed in the original method from the MacArthur Studies of Successful Aging described in Seeman et al (1997). Included measures were as follows: 1) systolic blood pressure (SBP), 2) diastolic blood pressure (DBP), 3) BMI (used as a proxy for waist-hip ratio), 4) total/HDL cholesterol ratio, 5) HDL cholesterol, 6) plasma norepinephrine, and 7) plasma epinephrine. Plasma catecholamines were used as a proxy for urinary catecholamines. The three Seeman indicators not included were DHEA-S, glycosylated hemoglobin, and urinary cortisol because we did not have these measures available. Participants received a point if they fell within the top quartile of values in the sample (or bottom quartile for HDL cholesterol, indicating the highest risk). A total allostatic load score was then computed for each participant by summing the number of indices for which participants received a point. Thus, the possible range of allostatic load scores was 0 (lowest possible risk score) to 7 (highest possible risk score).

Statistical Analysis

For our primary analysis, hierarchical linear regression was conducted in order to assess the relationship between caregiving status and allostatic load, controlling for age, sex, years of participant smoking history (irrespective of current smoking status), antihypertensive drug use, and cholesterol-lowering drug use. In the first step of the regression model, age, sex (female = 1; male = 0), years smoked, antihypertensive drug use (none = 0; antihypertensive use = 1), and cholesterol-lowering drug use (none = 0; cholesterol medication use = 1) were entered. In the second step, the dichotomous caregiving status variable (NC = 0; CG = 1) was entered.

For the secondary analyses, three separate hierarchical regressions were used in order to examine potential main effects of each psychological variable (i.e. mastery, depressive symptoms, and role overload) on allostatic load and the potential interaction between each psychological variable and caregiving status. Moderation effects were tested according to procedures described by Baron and Kenny (1986). All continuous variables were centered at their means in order to reduce multicollinearity between predictors and the interaction term. Binary variables were dummy coded. For each model, covariates were entered in step 1, as was done in the primary analysis. In step 2, the centered psychological variable and caregiving status were entered in order to assess main effects. Finally, in step 3, the caregiving status X psychological variable interaction term was entered. Follow-up tests for significant interaction effects were conducted according to procedures described by Holmbeck (2002), in which regressions were run for low (−1 SD) and high (+1 SD) levels of the psychological variable. This allows for assessment of the nature of the simple relationships between caregiving status and allostatic load at varying levels of the psychological variable.

Results

Participant demographic characteristics as well as mean values for allostatic load variables are presented in Table 1. CG and NC did not differ in age, and the majority of the participants were women and Caucasian with no CG/NC differences between these

variables. Fifty-six percent of CG and 51.2% of NC ($p > 0.050$) reported the use of one or more antihypertensive medications including β -blockers, α -blockers, mixed α - and β -blockers, diuretics, calcium channel blockers, angiotensin-converting enzyme (ACE) inhibitors, angiotensin II receptor antagonists, aldosterone antagonists, vasodilators, centrally acting adrenergic drugs, and α -2 agonists. Furthermore, 49.4% of CG and 30.2% of NC ($p = 0.038$) reported use of cholesterol-lowering medication including statins and niacin. On average, CG had been providing care to their spouse with Alzheimer's disease for 4.3 (SD = 3.4) years. There was no significant association between length of caregiving and allostatic load. CG also reported significantly less mastery ($p < 0.001$), more depressive symptoms ($p < 0.001$), and more overload ($p < 0.001$) compared to NC. These 3 measures were strongly correlated with each other (all $r_s \geq .54$).

The average allostatic load index score was 1.9 ± 1.3 for CG and 1.4 ± 1.3 for NC. This crude difference did not meet significance before controlling for covariates ($t(128) = 1.78$; $p = 0.076$), however Cohen's d was 0.4, suggesting a small to medium effect. The association between individual indicators of allostatic load and caregiving status was also assessed controlling for age, sex, years of participant smoking history, antihypertensive drug use, and cholesterol-lowering drug use. CG had significantly higher diastolic blood pressure compared to NC ($t(123) = 2.33$; $p = .021$). CG and NC did not significantly differ from each other on the remaining indicators.

Primary Analysis – Assessing the relationship between caregiving status and allostatic load

Results of the regression analysis are presented in Table 2. In Step 1, gender was the only covariate significantly associated with allostatic load ($t(124) = -2.53$; $p = 0.013$), such that men had elevated allostatic load compared to women. The addition of caregiving status in the second step of the regression model revealed a significant association between caregiving status and allostatic load ($t(123) = 2.02$, $p = 0.046$), such that CG exhibited higher allostatic load scores compared to NC independent of covariates. As a whole, the final prediction model accounted for 11.8% of the total variance in allostatic load ($F(6,123) = 2.74$; $p = 0.016$). Caregiving status uniquely accounted for 2.9% of the variance in allostatic load, which added a significant amount of explained variance to the model ($p = 0.046$).

Secondary Analyses – Testing the moderating role of psychological variables (personal mastery, depressive symptoms, and role overload) on the relationship between caregiving status and allostatic load

In the regression testing of the potential moderation effect of mastery on the relationship between caregiving status and allostatic load, there was no significant main effect of mastery in the second step of the model, and caregiving status remained significant ($t(122) = 2.19$; $p = 0.030$). In the third step of the model, there was a significant caregiving status X mastery interaction ($t(121) = 2.04$; $p = 0.043$). With the addition of the interaction term in the model, both caregiving status and mastery became insignificant. Male gender ($t(121) = -2.53$; $p = 0.013$) and use of antihypertensives ($t(121) = 2.17$; $p = 0.032$) were significant predictors of allostatic load in the final step of this model.

Post-hoc probing of this interaction suggested that the relationship between caregiving status and allostatic load was significant when mastery was high ($\beta = 1.01$; $t(121) = 3.00$; $p = 0.003$), such that CG with high mastery had higher allostatic load compared to NC with high mastery. When mastery was low, there was no relationship between caregiving status and allostatic load ($\beta = -0.07$; $t(121) = -0.17$; $p = 0.869$). Results indicated that CG with high mastery had the highest predicted allostatic load scores (2.4) compared to all other groups.

There were no main effects of depression or role overload in their respective models. Further, there was not a significant caregiving status X depression interaction or caregiving status X role overload interaction. The addition of depression and role overload in the second step of the models did not impact the significance of the caregiving status predictor ($p < .05$ in both regressions).

In order to verify the results of these moderation analyses, we re-conducted each of the analyses using dichotomized versions of each psychosocial variable (mastery, depression, role overload). Specifically, psychological variables were dichotomized using a median-split, such that “0” indicated low levels (below the median) of the variable and “1” indicated high levels (above the median) of the variable. Results indicated that none of the three psychological variables had significant main effects on allostatic load in the final step of the model. Dichotomized depression was the only variable to have a significant main effect in the second step of the model (covariates plus caregiving status and dichotomized depression, excluding the interaction term), such that depression was negatively associated with allostatic load ($t(121) = -2.10, p = .037$). There were no significant interactions between median-split psychological variables and caregiving status.

Exploratory Analyses – Testing potential mediating effects of depressive symptoms and role overload on the relationship between caregiving status and allostatic load

Given that depression symptoms and role overload can arguably be conceptualized as mediators of the relationship between caregiving status and allostatic load, Sobel tests of mediation were conducted to test the hypothesis that CG have elevated allostatic load compared to NC via increases in depression and/or role overload. Continuous versions of the CESD-10 and the Role Overload scale were used in analyses. Results indicated that neither depression (Sobel test statistic = $-1.07; p = 0.284$) nor role overload (Sobel test statistic = $-0.85; p = 0.397$) mediated the relationship between caregiving status and allostatic load.

Discussion

Our results indicated that allostatic load scores were an average of 0.5 points higher for CG compared to scores of NC, and that this difference was statistically significant with a small-medium effect size when controlling for associated covariates. This result supports the theory that individuals expected to have more frequent antecedent challenges (catalyzing allostatic responses) would exhibit more cumulative allostatic burden. This result is also consistent with previous findings suggesting that allostatic load is increased in chronically stressed individuals (Bellingrath, Weigl, & Kudielka, 2009; Gleib, Goldman, Chuang, & Weinstein, 2007; Glover, Stuber, & Poland, 2006; Kubzansky, Kawachi, & Sparrow, 1999), but inconsistent with findings from Clark et al. (2007) who did not find baseline CG/NC differences in allostatic load.

This finding raises the possibility that allostatic load may represent a potential mechanism linking caregiving stress to downstream health consequences. Moreover, this finding provides further evidence that Seeman and colleagues' (1997) widely-used conceptualization of allostatic load (modified for our current study) does indeed distinguish between “stressed” (i.e. CG expected to have increased levels of chronic stress) and “non-stressed” (married adults not experiencing similar stressors) groups.

It is important to note that the effect of caregiving status on allostatic load was small-medium, and that there are several potential explanations for why CG/NC differences were not more pronounced. First, it is possible that our CG sample might have been “healthier” relative to the general caregiver population, given the inclusion criterion that participants be free of severe physical and mental health problems. Further, CG who are highly burdened

with care responsibilities and/or their own health problems may have been less likely to volunteer for a research study. In addition, our ability to recreate Seeman et al.'s (1997) allostatic load quantification was somewhat limited. For example, CG/NC differences might have been greater if we had complete access to biomarkers included in the original quantification of allostatic load (i.e., DHEA-S, glycosylated hemoglobin, and urinary measures of cortisol, epinephrine, and norepinephrine).

Interestingly, mastery emerged as a significant moderator of the relationship between caregiving status and allostatic load. However, the nature of the interaction was contrary to our predictions, such that CG had significantly higher allostatic load compared to NC when mastery was high, and not when mastery was low. Although previous investigations have found that mastery may exert a protective effect on health outcomes related to caregiving stress (Mausbach, Mills, et al., 2007; Mausbach, et al., 2006; Roepke, et al., 2008; Roepke, et al., 2009), there have been other studies with opposing findings. One particular study by Seeman (1991) found that high mastery independently predicted coronary artery disease (CAD) risk in adult patients with suspected CAD above and beyond traditional risk factors. Seeman postulated that these findings may reflect the "cost of coping." That is, mastery may pose a damaging effect, regardless of successful or unsuccessful outcomes, because of the mental and physical costs of coping (Cohen, Evans, Stokols, & Krantz, 1986). The evidence for this postulation is mixed, with some investigations finding that those with high personal mastery have increased sympathetic arousal when confronted with difficult (Manuck, Harvey, Lechleiter, & Neal, 1978) and uncontrollable (DeGood, 1975; Houston, 1972) tasks, and others finding that high mastery was related to reduced sympathetic reactivity to stressful tasks (Roepke, et al., 2008). Given these mixed results, it is possible that there may be a third moderating variable that we have not identified that might explain why positive coping strategies are beneficial in some conditions and unhelpful in others. More work needs to be done to identify these potential factors in order build our understanding of how psychological processes impact health and disease.

An alternative interpretation of this unexpected finding may be that CG with high levels of mastery may actually have an unrealistic sense of control. Given that the course of Alzheimer's disease and the resulting obstacles are actually somewhat uncontrollable, CG who believe that they have a great deal of control over their future circumstances may actually be at risk for future frustration. A study examining irrational beliefs, locus of control, depression, and physical health in Alzheimer CG and controls found that endorsement of irrational beliefs, external locus of control, and stressful life events were related to depression and poorer health (McNaughton, Patterson, Smith, & Grant, 1995). Among other research suggesting that an unrealistic sense of control may have disadvantages (Janoff-Bulman & Brickman, 1982; Reuven-Magril, Dar, & Liberman, 2008), one study found that one's perceptions of the preventability of certain health problems and diseases may lead to false optimism about one's actual risk (N. D. Weinstein, 1982), which may result in ignoring important health habits and possibly poor adherence to medication. More research investigating the relationship between constructs of control in the caregiving context would help build the understanding of the complex relationship between caregiving, sense of control, and psychological and physical health consequences. Importantly, this finding was not replicated in our analysis using a dichotomized (median split) version of mastery, and therefore it should be interpreted with caution.

Contrary to prediction, we were unable to identify moderating effects for depressed mood or burden. Although we cannot be certain of the exact reasons for why these variables hypothesized to play an important role in the translation from environmental stress to allostatic load did not emerge as significant moderators, we propose some factors to consider. One potential explanation may be that responses to the psychosocial interview

only reflect a participant's experience at the present moment. Previous investigations have demonstrated that self-reports of psychological variables, such as positive and negative affect, do indeed fluctuate over time (Mausbach, Coon, Patterson, & Grant, 2008). Therefore, it is possible that data collected at a single moment in time may not accurately reflect the accumulation of caregiving stress or the consistency of mood or burden over time. Furthermore, the caregiving literature on the relationship between role overload and physical health outcomes has been somewhat mixed, with some studies finding that overload is associated with poorer physical health outcomes (Mausbach, Mills, et al., 2007), and others finding no such relationship (von Känel, et al., 2010).

One limitation important to identify is that this study was cross-sectional, and therefore causal conclusions cannot be drawn from these findings. Furthermore, we were somewhat limited in our ability to recreate an allostatic load variable according to the original quantification by Seeman and colleagues (1997). In their original study, the investigators collected a 12-hour urinary measurement of epinephrine and norepinephrine which provides information about catecholamine activity over time. This makes urinary measurements of catecholamines useful indicators of chronic stress. Indeed, previous work has found urinary catecholamine levels to be elevated in those experiencing chronic stress (Brown, James, & Mills, 2006; Davidson & Baum, 1986). It is possible that greater CG/NC differences might have been found on these variables using urinary measurements. However, a review by Dimsdale and Ziegler (1991) argued that although measurement of plasma venous norepinephrine as an indicator of sympathetic nervous system activity is complicated by several physiologic considerations (e.g., reuptake, varying organ clearance rates, cardiac output), there is a great deal of evidence in the literature linking it to several cardiovascular pathophysiological states including hypertension, congestive heart failure, and severity of myocardial infarction. They further add that plasma venous catecholamines are highly sensitive to stress. Given that available data was limited to single measurements of plasma catecholamines, precautions were taken to assure that blood draws were exclusively conducted in the morning (8AM to 10AM) in order to minimize variability due to diurnal fluctuations. All in all, our allostatic load variable did include biological indicators reflecting functioning of multiple physiological systems and did seem to represent a cumulative cost of antecedent challenges, given that it was significantly elevated in stressed CG compared to NC.

In summary, chronically stressed Alzheimer's CG exhibited elevated allostatic load compared to similar individuals not providing such care. The findings of this study provide contributions to both the caregiving stress and allostatic load literatures. Specifically, these results are consistent with theory that caregiving stress may translate to increased risk for downstream physical health outcomes via allostatic load. Furthermore, few investigations have examined allostatic load differences in a group characterized as being chronically stressed as compared to a group that is not. These results provide construct validity for the allostatic load quantification derived by Seeman et al. (1997), which was modified somewhat for our study. However, more work needs to be conducted in order to gain a better understanding of how mastery, mood, and burden might affect one's psychological and physiological response to environmental stressors. The results of our investigation of psychological variables as moderators in the relationship between caregiving status and allostatic load invite research to clarify the role of psychological variables in the translation of Alzheimer caregiving stress to physical outcomes.

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Table 1

Participant Characteristics

	Caregivers (N = 87)	Non-caregivers (N = 43)	<i>p</i> -value
<i>Demographic Information</i>			
Age, M (SD), y	74.3 (7.8)	74.9 (6.8)	.675
Gender, n (%)			.219
<i>Men</i>	25 (28.7)	17 (39.5)	
<i>Women</i>	62 (71.3)	26 (60.5)	
Ethnicity, n (%)**			.140
<i>Caucasian</i>	83 (95.4)	38 (88.4)	
<i>Non-Caucasian</i>	2 (2.3)	4 (9.3)	
Education, n (%)			.190
<i>Less than high school</i>	1 (1.1)	2 (4.7)	
<i>High school</i>	17 (19.5)	3 (7.0)	
<i>Some college</i>	27 (31.0)	11 (25.6)	
<i>College graduate</i>	42 (48.3)	27 (62.8)	
Monthly Household Income [§] , \$, median	4500	4200	.950
<i>Medical Information</i>			
Years of smoking cigarettes, M (SD)	9.0 (12.4)	8.1 (12.8)	.709
Using Antihypertensive Drugs, n (%)	49 (56.3)	22 (51.2)	.582
Using Cholesterol-lowering Drugs, n (%)	43 (49.4)	13 (30.2)	.038
<i>Psychosocial Variables</i>			
Personal Mastery, M (SD)	11.3 (3.3)	14.9 (3.8)	<.001
Depressive Symptoms (CESD-10), M (SD)	8.5 (5.6)	2.9 (4.6)	<.001
Role Overload, M (SD)	5.3 (3.2)	1.5 (2.2)	<.001
<i>Allostatic Load Indicators and Score</i>			
Systolic Blood Pressure, mm Hg, M (SD)	134.1 (15.1)	129.9 (13.3)	.127
Diastolic Blood Pressure, mm Hg, M (SD)	75.5 (8.4)	72.2 (10.7)	.063
Body Mass Index, M (SD)	26.4 (4.7)	25.5 (5.4)	.330
Total/HDL Cholesterol Ratio, M (SD)	3.6 (1.1)	3.7 (1.2)	.653
Plasma Epinephrine, pg/mL, M (SD)	32.5 (15.0)	28.9 (10.9)	.160
Plasma Norepinephrine, pg/mL, M (SD)	514.1 (214.5)	498.8 (194.4)	.694
HDL Cholesterol, mg/dL, M (SD)	51.6 (16.1)	52.0 (15.7)	.893
Allostatic Load Score, M (SD)	1.9 (1.3)	1.4 (1.3)	.076
Adjusted Allostatic Load Score, M (SE)	1.9 (0.2)	1.4 (0.1)	.046

Note. P-values reflect the significance for independent samples t-tests assessing caregiver/non-caregiver differences on study variables, with the exception of the adjusted allostatic load score.

** 2 caregivers and 1 non-caregiver declined to disclose their race; data is based on 127 participants.

[§] 12 participants declined to disclose household income information; data is based on 118 participants.

Table 2

Regression Model Predicting Allostatic Load Scores

	ΔF	df	p-value	ΔR^2	Entered Variables	B	SE	Partial Corr.
Step 1	2.41	124	0.040	0.09	Intercept**	3.72	1.20	
					Age	-0.02	0.02	-0.13
					Female*	-0.63	0.25	-0.22
					Years Smoked	-0.01	0.01	-0.07
					Antihypertensive Medication	0.45	0.24	0.17
					Cholesterol-lowering Medication	0.03	0.24	0.01
Step 2	4.08	123	0.046	0.03	Intercept**	3.37	1.20	
					Age	-0.02	0.02	-0.13
					Female**	-0.68	0.25	-0.24
					Years Smoked	-0.01	0.01	-0.08
					Antihypertensive Medication	0.44	0.23	0.17
					Cholesterol-lowering Medication	-0.06	0.24	-0.02
					Caregiver*	0.50	0.25	0.18

* p < 0.05

** p < 0.01