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Engagement in pleasant leisure activities and blood pressure: A 5-year longitudinal study in Alzheimer's caregivers

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Abstract

Objective—Elevated blood pressure is a significant public health concern, particularly given its association with cardiovascular disease risk, including stroke. Caring for a loved one with Alzheimer's disease has been associated with physical health morbidity, including higher blood pressure. Engagement in adaptive coping strategies may help prevent blood pressure elevation in this population. This 5-year longitudinal study examined whether greater participation in pleasant leisure activities was associated with reduced blood pressure in caregivers.

Methods—Participants were 126 in-home spousal Alzheimer caregivers (mean age = 74.2 ± 7.9 years) that completed five yearly assessments. Linear mixed effects models analysis was used to examine the longitudinal relationship between pleasant leisure activities and caregivers' blood pressure, after adjusting for demographic and health characteristics.

Results—Greater engagement in pleasant leisure activities was associated with reduced mean arterial blood pressure (MAP; $B = -0.08$, $SE = 0.04$, $p = 0.040$). Follow-up analyses indicated engagement in activities was significantly associated with reduced diastolic ($B = -0.07$, $SE = 0.03$, $p = 0.030$) but not systolic blood pressure ($B = -0.10$, $SE = 0.06$, $p = 0.114$). In addition, MAP was significantly reduced when caregiving duties ended because of placement of care recipients in nursing homes ($B = -3.10$, $SE = 1.11$, $p = 0.005$) or death of the care-recipient ($B = -2.64$, $SE = 1.14$, $p = 0.021$).

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Conflicts of Interest All authors declare no conflicts of interest.

Conclusions—Greater engagement in pleasant leisure activities was associated with lowered caregivers' blood pressure over time. Participation in pleasant leisure activities may have cardiovascular health benefits for Alzheimer's caregivers.

Keywords

cardiovascular disease; hypertension; dementia; elderly; behavioral activation

Introduction

Providing care to a disabled loved one is a highly stressful experience associated with increased risk for cardiovascular disease (CVD) (1, 2) and mortality (3), with caregiving-related stress being a key predictor of CVD onset (4). This increased CVD risk may be due, in part, to stress-related risk of developing hypertension. Specifically, Shaw and colleagues (5) found that, relative to their non-caregiving peers, Alzheimer's caregivers were at 67% increased risk for developing hypertension over a 3-year period. Capistrant, Moon, and Glymour (6) found that current caregiving was associated with a 36% increased risk of incident hypertension, whereas long-term caregiving was associated with nearly 2.5-times the risk of incident hypertension.

Hypertension is the strongest and most robust risk factor for CVD (7, 8). Optimal blood pressure has been defined as systolic blood pressure (SBP) less than 120 mmHg and diastolic blood pressure (DBP) less than 80 mmHg (9, 10). Risk for incident CVD increases 30–50% as SBP rises to levels between 120–129 mmHg or DBP rises to levels between 80–84 mmHg, and approximately doubles when SBP is between 130–139 mmHg or DBP is between 85–90 mmHg (11). Across middle-age to older adulthood, there is a positive linear relationship between blood pressure and CVD risk such that each 20 mmHg rise in SBP above 115 mmHg, or 10 mmHg rise in DBP above 75 mmHg is associated with approximately a two-fold increased risk for stroke, ischemic heart disease, or other vascular conditions (12). While these reports provide evidence of the independent effects of SBP and DBP on CVD outcomes, other studies have noted that long-term CVD risk is best made based on the combination of both SBP and DBP (i.e., mean arterial pressure), as MAP was found to be a strong predictor of both long-term CVD outcomes and all-cause mortality (13).

There is increased sympathetic and reduced cardiac vagal drive in the early stages of hypertension, whereas in established hypertensive states, sympathetic hyperactivity with catecholamine spillover predominates (14). Sympathetic overdrive in hypertension can stem from an excessive autonomic response to real-life stress (14). Plasma norepinephrine levels have been found to be higher in Alzheimer caregivers with high life stress compared to their counterparts with low life stress (15), and time spent caring for the spouse with dementia was positively associated with plasma norepinephrine levels in caregivers with low leisure satisfaction, but not in those with high levels of satisfaction (16). Exaggerated mental-stress induced blood pressure reactivity also appears to predict a sustained hypertensive state as well as subclinical atherosclerosis (17).

While adverse stress may be implicated in the pathogenesis of elevated blood pressure, positive coping behaviors may be associated with a reduction in blood pressure (18). This has led to research focused on behavioral factors that may prevent hypertension. One such behavioral factor is increased engagement in pleasant leisure activities. We have previously reported that increased engagement in pleasant leisure activities is cross-sectionally associated with lower blood pressure in Alzheimer's caregivers (19). Engagement in leisure activities appears to be acutely associated with reduced experience of adverse stress (20) and increased experience of positive mood states (20, 21). In Alzheimer's caregivers, increased engagement in pleasant leisure activities has been found to have a longitudinal association with reduced systemic low-grade inflammation (22), which, in the elderly, is implicated in arterial stiffening that plays an important role in CVD (23). Accordingly, engagement in leisure activities has also been linked with significant reductions in daily heart rate (20) and ambulatory SBP and DBP (24), which may be mechanisms by which leisure achieves its protective effects on blood pressure over time. These correlational and cross-sectional links between leisure engagement and blood pressure call for longitudinal repeated measures designs to demonstrate an association between leisure activity and blood pressure over time. Demonstration of a longitudinal association is an important step toward identifying potential mechanisms and treatment targets for individuals at risk for hypertension or elevated blood pressure.

Given that Alzheimer's caregivers are a population at risk for developing hypertension (5), and that positive coping behaviors among caregivers, such as engagement in pleasant leisure activities, may be associated with reductions in cardiovascular biomarkers as well as blood pressure (18), the aim of the current study was to examine the longitudinal association between caregivers' engagement in leisure activities and blood pressure over a 5-year period. We hypothesized that greater engagement in pleasant leisure activities would be significantly associated with decreased blood pressure over time.

Methods

Participants

Participants were 126 caregivers enrolled in the UCSD Alzheimer's Caregiver Study; a longitudinal study designed to evaluate the temporal associations between stress, coping, and risk for CVD. To be eligible, participants were required to: 1) be providing in-home care to a spouse with a physician diagnosis of probable Alzheimer's disease, and 2) be at least 55 years of age at enrollment. Participants were excluded if they: 1) reported a diagnosis of cancer, heart failure, myocardial infarction, or stroke in the 12-months prior to enrollment in the study, 2) suffered from severe hypertension (i.e., >200/120 mmHg, or 3) were taking medications known to affect biomarkers of specific interest to the study design (e.g., oral or parenteral steroids; anti-coagulant medications). Participants were not excluded if they were taking anti-hypertensive medications.

All participants were recruited through local community agencies serving older adults and/or caregivers, community health fairs, and through referrals from enrolled participants. Recruitment was staggered, with 78 participants recruited in year 1 of the study, 44 recruited in year 2, and 4 recruited in year 3. Caregivers were assessed annually through year 5, resulting in fewer than five possible assessments for participants recruited after year 1 (e.g., a participant recruited in year three could only complete a maximum of three assessments).

All caregivers gave informed consent to participate in the study, which was approved by the UCSD Institutional Review Board.

Procedure

All assessments were completed in the caregivers' homes. On an annual basis over a 5-year period, trained research assistants administered a psychosocial interview which included assessment of demographic information, caregiver health and health behaviors, and caregivers' engagement in pleasant leisure activities. Following these psychosocial interviews, a research nurse completed a physical examination that included three blood pressure measurements.

Measures

Blood Pressure—Caregiver blood pressure readings were obtained using a non-invasive Microlife blood pressure monitor with the participant in the supine position. Three BP measurements were collected over a 15-minute period, with the participant resting for 5 minutes in between each measurement. The mean of these three measurements was used as a measure of resting systolic and diastolic BP, and from these readings each participant's mean arterial pressure (MAP) was computed as [DBP + 1/3(SBP – DBP)]. To avoid diurnal effects, BP assessments were completed between 8:30 am and 10:30 am.

Engagement in pleasant leisure activities—The Pleasant Events Schedule-Alzheimer's Disease (PES-AD) (25) was used to assess caregivers' engagement in pleasurable leisure activities. The PES-AD was based upon the original Pleasant Events Schedule (PES) developed by MacPhillamy and Lewinsohn (26) and was based on behavioral theories of depression which theorize that depressive symptoms are the outcome of low rate of response-contingent positive reinforcement (27). In recognition that not all activities are equally enjoyable to all people, the original PES asked individuals to rate both the frequency with which they engaged in 320 activities over the previous month, as well as the subjective enjoyability of the activity. The product of these two ratings represents the amount of "obtained pleasure" from the activities. Since the development of the original PES, several measures have been developed using the same cross-product scoring to capture the level of obtained pleasure from leisure activities (28–30), of which the PES-AD is the shortest. Specifically, the PES-AD measures the frequency with which participants engaged in 20 pleasant activities (e.g. "listening to music", "being outside" or "watching TV") over the past month. For each of the 20 items, response options were 0 = not at all, 1= a few times (1–6 times), and 2 = often (7 or more times). In addition, participants were asked how much they enjoyed each of the activities (0 = not at all, 1 = somewhat, and 2 = a great deal). Standard scoring was then employed, in which a cross-product of the frequency and pleasure scores was created for each item as a reflection of the pleasure derived from the activity. The sum of these cross products was created as an overall reflection of the participants' engagement in in pleasant activities. Cronbach's alpha at the baseline assessment was .80.

Caregiver stress—The Pearlin Role Overload scale was used to capture overall level of stress experienced by caregivers (31). This scale consists of 4 items asking caregivers how much each statement describes them (e.g., "you have more things to do than you can handle”, “you work hard but never seem to make any progress”). Response options ranging from 1= not at all to 4= completely. Cronbach alpha for this scale at the baseline assessment was .76.

Sociodemographic and health characteristics and caregivers’ transitions— Information about caregivers’ age, years caregiving, and sex were assessed. In addition, caregiver body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared (kg/m^2). Participants were asked to report whether they had ever been a smoker during their lifetimes, including currently. Level of physical activity was assessed using the Rapid Assessment of Physical Activity (RAPA) scale (32), which assesses typical weekly level of physical activity. This scale was designed to measure physical activity for adults older than 50 years old, and it consists of nine items measuring the frequency and duration of engagement in light, moderate, and vigorous exercise in a typical week. Responses ranged from 0 to 6, with higher scores indicating higher level of physical activity.

Medications—During their psychosocial interviews, caregivers provided a list of all medications, both prescription and over-the-counter, they had taken in the previous 30 days. Use of anti-hypertensive medications was noted for use as a covariate in statistical analyses.

Statistical Analysis

Linear mixed effects models analysis with random intercepts and restricted maximum likelihood (REML) estimation was conducted to evaluate the association between engagement in pleasant leisure activities and BP, after adjusting for the effects of demographic, health characteristics, and caregiving transitions. The primary model included mean arterial pressure (MAP) as the dependent variable and both stress (overload) and engagement in leisure activities as independent variables. Secondary models included SBP and DBP as dependent variables. Key variables potentially associated with increased BP were included as covariates. These covariates were: age (33), sex (34), years caregiving, BMI (35, 36), history of smoking (37, 38), engagement in physical activity (39), and use of anti-hypertensive medications (40). Each of these variables, with the exception of sex, were entered as time varying covariates. There is theoretical and scientific evidence suggesting that cessation of caregiving duties via placement of the care recipient (CR) into long-term care, or with the death of the CR, produces physiologic benefit to caregivers that may result in lower BP (41, 42). Thus, placement and death of the CR were entered as time-varying covariates into our model to evaluate if these transitions were associated with reduced BP.

Finally, to compute effect sizes for significant linear predictors in our model, we computed the marginal R^2 [i.e., $R^2_{LMM(m)}$] statistic (43) with and without the significant predictor. From these overall R^2 values, we estimated change in R^2 as the differences in overall R^2 between the two models. For binary outcomes (e.g., placement) we computed Cohen’s d effect sizes as per the method described by Feingold (44), with standard effect estimates of 0.2, 0.5, and 0.8 deemed small, medium, and large, respectively (45).

Results

Demographic and Health Characteristics

Baseline demographic and health characteristics of the sample and descriptive information (means and standard deviations) of the assessed variables at each assessment are presented in Table 1.

Dropouts/Missing Data

Staggered enrollment resulted in differences in the number of possible assessments completed by each participant. These numbers do not reflect attrition as participants who missed one assessment were eligible to return for later follow-ups. Of the 126 participants who completed a baseline assessment, 115 (91.3%) completed a 12-month follow-up and 109 (86.5%) completed a 24-month follow-up. One hundred (82.0%) of the 122 available participants completed a 36-month follow-up, and 49 (62.8%) of the 78 available participants completed a 48-month follow-up. Thirty-eight participants missed one scheduled follow-up, three missed two follow-ups, six missed three follow-ups, and six missed four follow-ups. Of the 578 total possible assessments, 501 were completed (86.7%). Cox proportional hazards regression models were fitted to obtain the hazard ratios (HR) and 95% confidence intervals for baseline pleasant leisure activities scores on placement and death of the care recipients. Results showed that engagement in pleasant leisure activity at baseline was not significantly associated with care recipient placement (HR = 0.98; 95% CI = 0.96–1.01, $p = 0.123$) or death (HR = 1.00; 95% CI = 0.97–1.02, $p = 0.739$).

Using t-tests and chi square tests for linear and categorical variables, respectively, we explored whether participants who missed an assessment at a particular year were significantly different from participants who completed that assessment on baseline values of variables of interest to this study. Results indicated that at 12-months, 24-months, 36-months, and 48-months, participants who missed the assessment were not significantly different from completers with regards to age, BMI, RAPA score, caregiver stress, engagement in leisure activities, sex, smoking status, use of antihypertensive medication, or mean arterial pressure ($p > 0.05$ for all outcomes). Caregivers who underwent a care recipient placement ($p < 0.05$) or death ($p < 0.05$) were significantly less likely to miss an assessment than participants who remained caregivers for the duration of the study. Based on these analyses, we concluded that missing data was missing at random.

Association between Pleasant Leisure Activities and Blood Pressure over time

Participation in activities was high across the sample. Among the 20 activities listed on the PES-AD, the most frequently engaged activities were as follows: 1) Being outdoors (86.0% of caregivers reported doing this activity frequently), 2) Laughing (69.9%), 3) Watching TV (68.1%), 4) Listening to music (66.3%), and 5) Reading or listening to stories (65.5%). Exercise, which was assessed by a single item on the PES-AD, was frequently done by 49.4% of caregivers during the study period.

Prior to our adjusted analysis, we evaluated the unadjusted relationship between pleasant leisure activities and MAP via a linear mixed model analysis with only pleasant leisure activities as a predictor. Results of this analysis indicated that pleasant leisure activities were not significantly associated with MAP (B = −0.05, t = −1.48, p = .140). However, the results of the covariate-adjusted linear mixed model analysis for MAP are shown in Table 2. As depicted, greater engagement in pleasant leisure activities was significantly associated with lower MAP (B = −0.08, t = −2.06, p = 0.040), while higher BMI was significantly related to higher MAP (B = 0.47, t = 3.40, p = 0.001). In other words, engagement in pleasant leisure activities was significantly associated with lower MAP only when adjusting for other relevant factors. Additionally, both CR placement (B = −3.10, t = −2.80, p = 0.005) and CR death (B = −2.64, t = −2.31, = 0.021) were associated with significant decreases in MAP.

We also conducted several secondary analyses. In our first analysis, we sought to determine the association between frequency of activities and MAP. In this analysis, we used the sum of the frequency scores from the PES, which ignores the pleasure obtained from engaging in each activity. Results of this analysis indicated that frequency of activities was not significantly associated with MAP (B = −0.19, t = −1.94, p = 0.053). However, this result is not itself significantly different from the prior adjusted analysis taking into account the pleasure experienced in each activity. Therefore, it may be that engagement in activities alone is associated with lower MAP regardless of the pleasure derived in each activity.

A second set of analyses examined the associations between engagement in pleasant leisure activities and both SBP and DBP over time. Results indicated that greater engagement in leisure activities was associated with significant reductions in DBP (B = −0.07; t = −2.18, p = .030) but not SBP (B = −0.10; t = −1.58, p = 0.114).

Engagement in pleasant leisure activities at one assessment was not associated with engagement or blood pressure at future assessments. Specifically, there was no association between current engagement in leisure activities and MAP 1-year later (B = −.05, p = .244), or between current MAP and engagement in leisure activities 1-year later (B = .06, p = .163). However, this is somewhat expected given that assessments were conducted annually and the Pleasant Events Scale assesses caregivers' engagement in pleasant leisure activities over the past month.

A final set of analyses examined the correlations between individual activities and blood pressure outcomes over time. The first set of analyses examined the correlations between the frequency with which caregivers engaged in each activity and blood pressure. The second analyses examined the correlations between the derived pleasure from these activities (i.e., frequency × pleasure cross-products) and blood pressure outcomes. As expected, more frequent exercise was significantly associated with reduced mean arterial pressure (r = −.20). Other activities that were significantly associated with MAP included shopping (r = −.20), reading stories (r = −.28), and listening to music (r = −.17). Results of the entire set of activities are presented in the Supplemental Tables S1 and S2, Supplemental Digital Content 1.

Effect size estimates, as per the $R^2_{LMM(m)}$ statistic, indicated that the full model accounted for 12.7% of the overall variance in MAP. The additional variance accounted for by pleasant leisure activities was .014 (Pearson r = −0.12), which corresponds to a small effect.

Similarly, the additional variance accounted for by BMI was .038 (Pearson r = 0.19). The Cohen's d effect size for CR placement and CR death were estimated as 0.32 and 0.28, respectively, each of which corresponds to a small-to-medium effect size.

Discussion

The aim of this study was to analyze the longitudinal associations between engagement in pleasant leisure activities and blood pressure in a sample of Alzheimer caregivers. Consistent with our hypothesis, the results showed that caregivers who reported greater engagement in pleasant leisure activities demonstrated lower MAP over time, after adjusting for empirically relevant covariates such as sociodemographics (caregiver sex and age), stressors (overload), BMI, lifestyle behaviors (physical activity and smoking) and care-recipient placement or death. These results are consistent with, and add to the growing body of literature showing possible benefits of leisure activities to multiple indicators of well-being , including improved sleep quality (48), reduced daily heart rate (20), reduced ambulatory SBP and DBP (24), improved endothelial function (49), and reduced inflammation (22). Although pleasant leisure activities have been associated with reduced blood pressure cross-sectionally (19), this is the first study demonstrating longitudinal support for this association, suggesting that sustained engagement in leisure activities may have long-term benefits to caregivers' cardiovascular health.

Secondary analyses examined the association between the specific leisure activities and blood pressure over time. Results of these analyses revealed some expected associations, namely that greater engagement in exercise was associated significantly lower blood pressure. However, lower blood pressure appeared related to greater engagement in other, less expected activities such as reading stories, listening to music, shopping, and recalling past events. Given these activities are more sedentary and reflective in nature, it's possible that the impact of leisure activities on blood pressure is not isolated to physical activity.

While anti-hypertensive drugs are the standard of care for hypertension, the many individuals with borderline elevated BP should have lifestyle modifications to lower their BP. Engaging in more leisure activities represents a simple recommendation for caregivers to benefit physical well-being. While a clinical trial will be needed to establish that increasing leisure activity results in improved blood pressure profiles, there is preliminary evidence suggesting that leisure-based interventions may have benefits to caregiver blood pressure. In this regard, Moore et al. (46) reported that significant decreases in the inflammatory cardiovascular risk marker interleukin-6, which has been implicated in stress-related hypertension (50), were obtained for participants in a brief behavioral activation intervention compared to a control group. Although engagement in pleasant leisure activities was not measured in their study, their findings, in conjunction with those presented here, suggest that increasing the time spent on leisure activities may reduce caregivers' cardiovascular risk.

Beyond the relations between leisure activities and blood pressure, the results of this study also showed that CR placement and death are associated with significant reductions in blood pressure. These results add to the existing literature showing that upon placement or death of the CR, caregivers experience an immediate improvement in physical symptoms (51).

Furthermore, Mausbach et al. (41) found that although caregivers experience an acute, significant increase in levels of D-dimer (i.e., a hypercoagulability marker of increased cardiovascular risk) following a caregiving transition, those levels began to significantly decline at 6-months post-transition, suggesting that caregiver transition leads to a "normalization" of physiological health over time. The present study supports the notion that cessation of caregiving duties, either via placement or death of the CR, may result in improved cardiovascular profiles or reduced cardiovascular disease risk, for the caregiver.

The present study has several limitations. First, error associated with the use of self-reported measures for health habits (e.g. exercise) and BMI (52, 53) may reduce the precision with which these measures predict blood pressure. This could result in increased error variance ultimately captured by pleasant leisure activities that would otherwise be captured by health-related factors. However, this loss of precision may be offset by the fact that we measured blood pressure at caregivers' homes, which has been shown to more strongly predict CVD outcomes than blood pressure measured in other contexts (e.g., office, clinic), either because of the amount of blood pressure readings taken or due to the real-life conditions in which they are obtained (54, 55). We acknowledge that the gold standard method of BP measurement is 24-hour ambulatory BP, which covers issues not addressed by home BP measurements. These include the detection of nocturnal hypertension (i.e., non-dipping of BP during sleep) or of masked hypertension (i.e., BP is normal in the clinic/office, but elevated out of the clinic), the latter affecting 15% of the population and carrying cardiovascular risk equal to elevated home and office BP (56). Nevertheless, the strengths of the home monitoring approach should not be underestimated, as, along with ambulatory BP monitoring, home monitoring may help to detect both masked hypertension and white-coat hypertension (i.e. BP is elevated in the clinic/office, but normal out of the clinic). Home BP monitoring can provide information on day-to-day variability of BP and is also an excellent means to obtain variations in BP for weeks or months, including seasonal variations. with a high number of measurements that would be difficult with ambulatory BP monitoring (57). Particularly, self-measurements of day-by-day BP variability at home play an independent role in the pathogenesis of hypertension-induced cardiovascular damage (58). Compared to ambulatory BP monitoring, home monitoring is less expensive, less intensive and may also help to improve treatment adherence by giving patients a more active role in the management of hypertension (57).

Our study did not find a significant association between use of antihypertensive medications and blood pressure. However, caregivers who reported using these medications had, on average, lower MAP relative to those not taking them, albeit a non-significant difference. While failure to show a significant impact of blood pressure medications may seem unexpected, one explanation for this finding is that the benefits of using these medications had already occurred. Specifically, research suggests that among those with essential hypertension, SBP declines by a mean of 10 mm/Hg via use of antihypertensive medications (59). Because the effect of anti-hypertensive use was between-subjects rather than within-subjects, it is possible that those taking antihypertensives had already experienced significant benefit, possibly explaining why the effect of anti-hypertensives was non-significant in our analysis. A more thorough investigation on use of anti-hypertensive would be to examine within-person effects of anti-hypertensive use over time, or to set use of anti-hypertensives as an inclusion/exclusion criterion.

Our investigation did not evaluate reasons why caregivers were, or were not, engaging in pleasant leisure activities. For example, it is likely some caregivers did not to participate in the activities due to lack of interest, others might have been restricted from them due to their caregiving duties, and still others might have participated because they had family support to allow them "free time" or their care receivers were not as impaired. Each of these alternate reasons may themselves have contributed to variation in MAP, and each should be addressed in future studies.

Another limitation is the restricted manner in which we measured engagement in leisure activities. That is, engagement in pleasant leisure activities was conceptualized as the product of the frequency with which individuals engaged in activities and the amount of pleasure they obtained from them. While this conceptualization is consistent with behavioral theories of depression (27), other conceptualizations of leisure engagement may also be important to study, including activity restriction (60), leisure time satisfaction (61), and behavioral activation (62). In addition, a greater emphasis on breaking apart the unique effects of physical vs social leisure activities (63) may provide more information on the role of each in predicting health outcomes. Furthermore, the correlation between engagement in activities and blood pressure was nearly identical to the correlation between enjoyment from these activities and blood pressure. This may have been due to caregivers rating many of these activities as highly enjoyable when they were performed, which produced a minimal difference in ratings of frequency vs derived enjoyment. Thus, we highly recommend future research consider other means of evaluating engagement in pleasant leisure activities.

Additional limitations of the current study were the inclusion of only elderly spousal caregivers, investigation of only caregivers of individuals with Alzheimer's (as opposed to other forms of dementia), and the homogenous ethnic composition of the sample, all of which limit generalizability of our findings to younger, non-spouse, ethnically diverse, and non-Alzheimer's dementia caregivers. Additional research is needed to determine if engagement in pleasant leisure activities is associated with reduced blood pressure in these caregiver samples.

Although increased engagement in pleasant leisure activities is associated with reduced blood pressure, this result was significant in our adjusted model but not in a direct model that included only pleasant leisure activities as the predictor. This may have been due to a suppressor effect. Two candidate suppressor variables were the RAPA and Role Overload measures, as both were uncorrelated with MAP in our analyses. However, both of these scales were significantly correlated with engagement in pleasant leisure activities. This appears feasible since many caregivers may perceive exercise as an enjoyable activity, and greater caregiver stress is likely associated with reduced engagement in leisure activities.

In conclusion, our findings show that increased engagement in pleasant leisure activities is associated with reduced blood pressure over time in spousal Alzheimer caregivers. The demonstration of a longitudinal relationship between engagement in leisure activities and BP adds to the existing literature, demonstrating potential cardiovascular benefits of engaging in leisure activities, as well as cross-sectional literature showing relations between engagement in leisure activities and indicators of cardiovascular well-being. A secondary finding from this study was that cessation of caregiving duties, via placement or death of the CR, results in significant reductions in blood pressure, providing further evidence that cardiovascular health may improve once direct caregiving duties end. Future research should examine the acute and long-term impact of leisure-based interventions on blood pressure outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations

CVD	Cardiovascular Disease
BP	Blood Pressure
SBP	Systolic Blood Pressure
DBP	Diastolic Blood Pressure
MAP	Mean Arterial Pressure
PES-AD	Pleasant Events Schedule, Alzheimer's Disease
RAPA	Rapid Assessment of Physical Activity
BMI	Body Mass Index
CR	Care Recipient
HR	Hazard Ratio
CI	Confidence Interval
SE	Standard Error
M	Mean
SD	Standard Deviation

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Table 1

Characteristics of the sample

	Baseline (N= 126)	12-months (N=115)	24-months (N=109)	36-months (N=100)	48-months (N=49)
Age (years), M (SD)	74.15 (7.94)	75.39 (7.79)	76.44 (7.89)	77.68 (7.87)	78.79 (7.59)
Female, n (%)	89 (70.6)	80 (69.6)	78 (71.6)	69 (69.0)	34 (68.0)
BMI (kg/m^2), M (SD)	26.49 (4.71)	26.79 (5.20)	26.37 (5.10)	26.96 (5.08)	25.94 (3.92)
Ever Smoked, n (%)	58 (46.0)	53 (46.1)	48 (44.0)	48 (48.0)	24 (49.0)
RAPA, M (SD)	3.42 (1.64)	3.10 (1.37)	3.04 (1.73)	2.80 (1.61)	3.40 (1.56)
Taking Anti-Hypertensives, n (%)	76 (60.3)	75 (65.2)	69 (63.3)	69 (69.0)	30 (60.0)
CR Placed, n (%)	0 (0.0)	15 (13.0)	31 (28.4)	39 (39.0)	25 (50.0)
CR Deceased, n (%)	0 (0.0)	7 (6.1)	20 (18.3)	33 (33.0)	30 (60)
Stress: M (SD)	5.18 (3.15)	4.26 (2.99)	3.98 (2.91)	3.87 (2.91)	3.41 (2.65)
Pleasant Leisure Activities, M (SD)	30.83 (4.65)	31.10 (4.89)	30.87 (5.62)	29.47 (5.70)	30.20 (5.31)
Systolic BP (mmHg), M (SD)	134.31 (15.32)	131.82 (16.23)	130.16 (16.60)	131.16 (16.65)	127.55 (14.33)
Diastolic BP (mmHg), M (SD)	75.83 (8.57)	72.62 (9.65)	70.86 (9.53)	71.31 (10.35)	69.47 (7.90)
MAP, M (SD)	95.33 (9.62)	92.36 (10.62)	90.63 (10.73)	91.26 (11.19)	88.83 (8.61)

Note. M = mean; SD = Standard deviation; BMI = Body mass index; RAPA = Rapid Assessment of Physical Activity; CR = Care receiver; BP = Blood pressure; MAP = Mean arterial pressure.

Table 2

Linear mixed-effects model for mean resting arterial pressure over time

	B	SE	t-value	p-value
Intercept	92.83	1.00	92.48	<.001
Age	−0.20	0.10	−1.97	.051
Years Caregiving	0.01	0.23	0.05	.960
Female sex	−2.18	1.73	−1.26	.210
BMI	0.47	0.14	3.40	.001
RAPA	0.50	0.30	1.64	.102
Ever Smoked	0.88	1.32	0.67	.502
Taking Anti-hypertensives	−1.51	1.20	−1.26	.209
CR Placed	−3.10	1.11	−2.80	.005
CR Deceased	−2.64	1.14	−2.31	.021
Stress	−0.16	0.18	−0.90	.371
Pleasant Leisure Activities	−0.08	0.04	−2.06	.040

Note. BMI = Body mass index; RAPA = Rapid Assessment of Physical Activity; CR = Care recipient; B = unstandardized coefficient; SE = standard error. Age centered at 76 years; Sex = 0.5 for male, −0.5 for female; Years caregiving centered at 4 years; BMI centered at 26.57; RAPA centered at 3; Ever smoke = 0.5 for yes, −0.5 for no; taking antihypertensives = 0.5 for yes, −0.5 for no; CR placed = 1 for yes, 0 for no; CR deceased = 1 for yes, 0 for no; stress centered at 4.26; pleasant leisure activities centered at 54.40.

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