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RESEARCH ARTICLE

Relationship between cellular aging, perceived stress, and cardiometabolic disease risk in Black family caregivers of persons with dementia

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Abstract

BACKGROUND: Informal caregivers of individuals with Alzheimer's disease and related dementias (ADRD) face significant physical and psychological demands. Chronic caregiving is linked to mental health challenges, poor cardiovascular health, and accelerated cellular aging, reflected in telomere shortening, with Black caregivers disproportionately affected.

METHODS: This secondary analysis used data from Black caregivers from a randomized control trial. Telomere length was measured by qPCR. Questionnaires assessed perceived stress, sleep, depression, anxiety, and coping strategies. Salivary cortisol, inflammatory, and cardiometabolic biomarkers were measured. Pearson correlations and linear regression analyses controlled for demographic and health factors.

RESULTS: Shorter telomeres were linked to stress, poor sleep, inflammation, and cardiometabolic markers. Perceived stress was associated with negative coping strategies, anxiety, and depressive symptoms.

DISCUSSION: More research is needed to uncover mechanisms linking caregiver stress to cardiovascular health, guiding tailored interventions to reduce stress and improve cardiovascular health in Black caregivers of persons with ADRD.

KEYWORDS
Alzheimer's disease, caregiving, inflammation, race, stress, telomere

Highlights

- **Chronic stress in Black caregivers**: Chronic caregiving stress was linked to accelerated cellular aging, inflammation, and poor cardiometabolic health.
- **Perceived stress associations**: Higher perceived stress was associated with negative coping strategies, poor sleep quality, anxiety, depression, and reduced telomere length.

- **Telomere length and cardiometabolic risk**: Shorter telomere length was significantly associated with elevated cardiometabolic risk markers, including insulin resistance and increased blood pressure.
- **Need for interventions**: Findings emphasize the importance of culturally tailored interventions aimed at reducing stress and mitigating health risks in Black caregivers of persons living with Alzheimer's disease.

1 | BACKGROUND

In the United States, 1 in 9 adults aged 65 years or older is living with Alzheimer's disease or related dementias (ADRD).[1] The prevalence of ADRD in Black Americans is 64% higher than in non-Hispanic White (NHW) Americans.[2] Despite improvements in overall US health outcomes, Black Americans continue to be underserved and undertreated, experiencing higher morbidity and mortality from chronic illnesses including coronary heart disease, diabetes, and ADRD.[3,4] As the aging population becomes more racially diverse, the number of Black Americans with ADRD is expected to increase significantly, posing a critical challenge for family caregivers, communities, and healthcare professionals.[5]

Black caregivers play a critical role in the health and well-being of their care recipients, often serving as social service, welfare, and community-based intervention systems. These caregivers are typically women and predominantly daughters.[1] Despite the high prevalence of ADRD in their community, Black caregivers are less likely to access ADRD support services than NHW caregivers, with lower rates of admittance to assisted living facilities due to cost barriers.[6] They also report higher caregiving demands, worse physical health, and unmet support needs.[7] Black caregivers often experience worse health outcomes compared to NHWs and face higher risks for conditions like hypertension, depression, and stress-related illnesses due to the compounded burden of caregiving and systemic health disparities.[8]

Despite these challenges, many Black caregivers demonstrate notable resilience, the ability to adapt and recover from stress and adversity, often by leveraging coping strategies and social support systems, relying on strong cultural, familial, and community networks to buffer the negative impacts of caregiving stress.[9,10] Understanding the role of resiliency in Black caregivers is crucial to developing effective interventions that can enhance their health outcomes and quality of life.

Black caregivers are likely to identify with traditional values of providing care for dependent loved ones and are more likely to provide care within a network instead of providing individualistic care.[11] However, prior studies suggest that Black caregivers have fewer socioeconomic resources and social networks.[12] Another factor that may influence cultural values is the belief that care should be provided by the family. It is important to note that this may be a result of increased cost and financial pressures.[11]

Caregiving, especially for individuals with ADRD, is associated with chronic stress and numerous mental and physical health challenges.[13] However, caregiving benefits and challenges vary based on context, experience, and values.[11,14,15] Compared to White caregivers, Black caregivers report less life satisfaction and greater perceived rewards in their roles.[11,16–18] Compared to non-caregivers, caregivers experience poorer immune responses, slower wound healing, and an increased risk of hypertension, cardiovascular disease, diabetes, and higher mortality rates.[19,20]

Caregivers often experience accelerated cellular aging, as indicated by shorter telomere lengths.[21] Telomeres, the protective caps on the ends of chromosomes, shorten with stress and age, serving as biomarkers of biological aging and cardiovascular disease risk.[22] Although research specific to Black dementia caregivers is limited, evidence suggests that the compounded stress from caregiving and systemic health disparities may further accelerate telomere shortening in this population. As the population ages and caregiving demands grow, chronic stress and its negative effects on health will become more prevalent.

Here we examine the relationship among perceived stress, cellular aging, psychological health, cardiometabolic risk, and resiliency among Black family caregivers of individuals with Alzheimer's disease and related dementias. We hypothesize that caregivers self-reporting more perceived stress will experience poorer psychological health outcomes and shorter telomere lengths, all of which are associated with greater cardiometabolic risk factors.

By focusing on Black caregivers, this study aims to address gaps identified in the literature and identify the potential physiological impact of caregiving on Black caregivers. The results from this study will provide potential foci for outcomes of tailored interventions to support the health and well-being of Black caregivers.

2 | MATERIALS AND METHODS

2.1 | Conceptual framework and rationale

The conceptual framework for this study draws on social cognitive and stress-coping theories to explore the physiological impact of chronic stress. These models emphasize psychological and physiological responses to caregiving stress, focusing on cognitive appraisal and coping strategies. The cognitive appraisal process shapes coping behaviors. Coping strategies can either promote avoidance (emotion-focused coping), decrease proximity to stressors (problem-focused coping), or foster positive reappraisal (problem-focused coping).[23] In this framework, depression, sleep status, and other factors serve as

intermediate outcomes of the stress situation (e.g., caregiving); these are, in turn, linked to broader cardiometabolic risk. Additionally, the model considers the physiological disruptions caused by stress, particularly in the hypothalamic–pituitary–adrenal (HPA) axis and the sympathetic and parasympathetic nervous systems.[24]

To capture the multidimensional effects of stress, we selected a panel of biomarkers that operate across different biological systems and time horizons. Cortisol awakening response (CAR) reflects acute neuroendocrine function and daily HPA axis regulation. Inflammatory and metabolic markers (e.g., C-reactive protein [CRP], interleukin (IL) -6, insulin, adiponectin, resistin) represent intermediate biological risk pathways activated by chronic stress. Telomere length, by contrast, captures cumulative biological aging and cellular wear and tear. It is also increasingly recognized as a marker of embodied social disadvantage, shaped by long-term exposure to stressors such as systemic racism, caregiving demands, and limited access to formal support.

This study design reflects an integrative stress-aging model that connects perceived stress to physiological and psychological outcomes via both immediate and cumulative biological mechanisms. This framework also offers insights into potential pathways linking caregiving stress to long-term health risks, including cardiovascular disease and ADRD, especially in socially marginalized populations.

RESEARCH IN CONTEXT

1. **Systematic review**: We conducted a thorough literature review using traditional sources such as PubMed and relevant conference abstracts. The accumulated knowledge indicates that caregiving for individuals with Alzheimer's disease (ADRD) is associated with elevated stress and poor cardiometabolic outcomes, especially in marginalized populations. While much of the literature focuses on non-Hispanic White caregivers, few studies have examined Black caregivers, particularly the cellular aging processes related to chronic caregiving stress.
2. **Interpretation**: Our study demonstrates that perceived stress among Black ADRD caregivers is associated with negative health outcomes, including accelerated cellular aging, inflammation, and increased cardiometabolic risk. These findings align with existing evidence on caregiving stress but provide specific insights into its effects within Black American caregiving populations.
3. **Future directions**: Future research should explore longitudinal impacts of caregiving stress on cellular aging and cardiometabolic health. Additional studies are needed to assess the effectiveness of culturally tailored interventions aimed at reducing stress and improving health outcomes for Black caregivers.

2.2 | Study design

This secondary analysis of baseline data from the Caregiver Opportunities for Optimizing Lifestyles in Alzheimer's Disease (COOL-AD) randomized controlled trial (P01NR011587, ClinicalTrials.gov ID #NCT01188070) conducted at Emory University utilized previously collected baseline questionnaires, biomarker data, and stored biologic samples to add measures of total telomere length. COOL-AD was a combined psychoeducation (PE) and exercise (EX) intervention designed to promote health and well-being in Black ADRD caregivers, as previously described.[5] Data were collected at baseline prior to randomization and 6 months after the start of the program. All participants provided written consent before participation. The study was approved by the Institutional Review Board of Emory University (IRB00026244).

2.3 | Study sample

The total sample consisted of 142 Black family caregivers from Atlanta, GA, and surrounding areas, with 118 participants having stored DNA samples and included in this study. Individuals were recruited through various activities, including presentations to community groups, use of media materials, support from the Registry for Remembrance (P30AG066511), and the Alzheimer's Association. Study participants were family caregivers who self-identified as Black, were 21 years of age or older, and had a family member who was diagnosed with ADRD by a physician. Family caregivers were defined as co-residing or providing 6 h of care at least 4 days a week, consistent with prior work by our team and others. These criteria were intended to ensure participants had meaningful caregiving roles and sufficient exposure to caregiving-related stress. Similar thresholds have been used to identify caregivers likely to benefit from interventions and to capture those at greater risk for psychological and physiological burden.[25,26] Additional criteria included being cognitively unimpaired (as determined by a Blessed-Orientation-Memory-Concentration Test score < 10[27]), sedentary (defined as not engaged in moderate-strenuous exercise 3 days or more each week), and not under restriction to engage in exercise. Exclusion criteria included a medical/physical condition that precluded participation in exercise, regular use of steroids, acute inflammation, or a care recipient likely to be institutionalized within 6 months.

Sociodemographic and medical history were collected via self-report. Comorbidities were quantified using the Charlson Comorbidity Index (CCI), which estimates mortality risk by considering age, number of comorbidities, and severity of each comorbidity.[28] A higher CCI score is associated with a higher 1-year and 10-year mortality rate.[28]

2.4 | Assessments of psychological stress

2.4.1 | Depression

Caregiver depressive symptoms were measured using the Center for Epidemiological Studies Depression scale (CES-D). This 20-item

instrument measures self-reported depressive symptoms with somatic and psychological subscales.[29] The CES-D prompts participants to reflect on feelings or behaviors experienced in a given week (e.g., "I felt fearful," "I was happy," "I could not get going"). Caregivers rate the frequency of occurrence on a 4-point Likert scale ranging from 0 "Rarely" to 3 "Most all of the time." Scores range from 0 to 60, with higher scores indicating higher prevalence of depressive symptoms. Validity and reliability have been well established in the general population, and they have also been well established in caregivers of persons living with ADRD.[29] Cronbach's alpha was 0.85.

2.4.2 | Anxiety

The State Trait Anxiety Inventory (STAI) was used to measure symptoms of anxiety. The STAI is a 40-item questionnaire with two 20-item subscales that assess state and trait anxiety.[30] The state subscale measures anxiety as a transitory emotional state. Each item presents a feeling (e.g. "I am tense," "I am worried," "I feel calm"), and participants rate the frequency with which they have experienced it on a four-point Likert scale ranging from "almost never" to "almost always." The trait subscale assesses anxiety as a stable personality trait. Participants rate the frequency of occurrence (e.g., "I worry too much over something that doesn't matter," "I am content," "I am a steady person"). The state subscale was used in this study to examine changes in transitory anxiety. Total scores range from 20 to 80, with higher scores indicating higher symptoms of anxiety.[30] Cronbach's alpha for the state scale was 0.94.

2.4.3 | Perceived stress

Perceived stress was measured using the Perceived Stress Scale (PSS). The PSS assesses caregivers' thoughts and feelings over the previous month.[31] It also prompts participants to reflect on how often they have felt as if their life was unpredictable or uncontrollable. Participants respond to the 14-item questionnaire on a 5-point Likert scale. Total scores range from 0 to 40. Larger scores indicate higher levels of perceived stress.[31] Internal consistency was reported to be 0.84 or higher.

2.4.4 | Coping responses

To assess what strategies participants use to navigate stress and adversity in everyday life, the Ways of Coping Questionnaire (WCQ) was used. The 42-item scale provides insight into three types of coping responses: method-focused coping, problem-focused coping, and emotional-focused coping.[32] Participants respond to each item on a four-point Likert scale, indicating how often they engage in each coping strategy. There are eight subscales within the WCQ that align with these categories: Confrontive coping describes aggressive efforts to alter a stress-inducing situation. This often is associated with some degree of hostility and risk-taking. Distancing involves cognitive efforts to detach oneself and minimize the significance of a situation. Self-controlling coping describes an individual's efforts to regulate their feelings. Seeking social support describes a coping practice in which an individual seeks out information and tangible and emotional support. Accepting responsibility is often seen when an individual acknowledges their role in a conflict and works to alleviate the problem. Escape avoidance includes engaging in behavioral efforts to avoid a problem through acts such as wishful thinking. Planful problem solving is the practice of problem-focused coping in which an individual makes efforts to change a situation. Positive reappraisal arises when an individual creates positive meaning from adverse situations. The WCQ coping scales exhibited good reliability with Cronbach alpha coefficients ranging from 0.61 (distancing) to 0.79 (positive reappraisal).[32]

2.4.5 | Caregiver burden

Caregiver burden was measured using the Zarit Burden Interview (ZBI). The 22-item scale questionnaire has two subscales.[33] Personal strain refers to the emotional and psychological distress experienced by the caregiver. Role strain focuses on the challenges associated with the responsibilities of providing care. Participants respond on a five-point Likert scale. Scores range from 0 to 88, with higher scores reflecting greater burden.[34] The reliability of total strain, personal strain, and role strain are $\alpha = 0.92$, $\alpha = 0.846$, and $\alpha = 0.850$, respectively.

2.5 | Assessments of physiologic stress

2.5.1 | Blood collection

Following overnight fasting, blood was collected at Emory University using an intravenous catheter placed into a forearm vein. Samples were collected in ethylenediaminetetraacetic acid (EDTA), heparin, or tempus tubes and immediately placed on ice. Samples were processed and stored at −80°C until analyses.

2.5.2 | Cellular aging

Total telomere length and telomerase levels were used as biomarkers of cellular aging. DNA was extracted from stored biologic (buffy coat) samples (DNeasy Blood & Tissue Kit, Qiagen, Germantown, MD). DNA was quantified using the NanoDrop Microvolume Spectrophotometer (ThermoFisher, Waltham, MA). Total telomere length was assayed in duplicate by quantitative polymerase chain reaction, per manufacturer's instruction (Absolute Human Telomere Length Quantification qPCR Assay; Sciencell Research Laboratories, Carlsbad, CA, USA). Polymerase chain reaction products were then analyzed using gel electrophoresis.

2.5.3 | Salivary cortisol

The HPA-axis function was measured using salivary CAR. Assessing cortisol concentrations in saliva is widely used to examine neuroendocrine function and psychological effects.[35,36] After awakening, there is a rapid increase in cortisol secretion from the adrenal gland, followed by a decline in cortisol levels throughout the day. HPA-axis dysfunction and cortisol dysregulation are associated with risk of coronary artery disease and negative psychological affect.[37] This dysfunction is typically correlated with impaired diurnal cortisol decline.[38] CAR has been used as a measure of physiologic stress in prior caregiving research.[39,40]

Participants collected salivary samples at home upon awakening and 30 min later across 2 days. They were provided with detailed instructions modeled after Mathews.[38] An enzyme-linked immunosorbent assay (ELISA) assay was conducted to measure salivary cortisol levels. All samples were assayed in duplicate. CAR was calculated as the percent change between the average waking values and the average values 30 min after waking. The assay has a sensitivity of 0.1 ug/dL. Intra- and inter-assay coefficients of variation are < 8% and < 11%.

2.5.4 | Biochemical markers of cardiometabolic disease

Caregiver cardiometabolic disease risk factors were assessed with CRP, IL-6, plasminogen activator inhibitor type 1 (PAI-1), adipocytokines, and a lipid profile. All measures were quantified with immunoassay.

CRP is an acute phase protein secreted by the liver that is an inflammatory marker associated with cardiovascular disease (CV) and insulin resistance.[41] Levels of > 3.0 mg/L are consistent with a high risk for CV disease. IL-6 is a pro-inflammatory cytokine secreted by macrophages and lymphocytes. It is also involved in the pathogenesis of insulin resistance, which contributes to an increased risk of CV disease.[42] PAI-1 is an acute phase protein known for its pro-thrombotic and pro-inflammatory effects on vascular endothelium that indicate endothelial dysfunction and an increased risk for CV disease[42]. Adipokines play a key role in inflammation and endothelial function. Adiponectin and resistin are proteins produced by adipocytes that have reciprocal effects on endothelial cells.[43] Adiponectin has anti-inflammatory and antioxidant effects[37]. It also plays an important role in regulating insulin sensitivity. Resistin has pro-inflammatory properties, which are integral to insulin resistance. Dysregulation of adipokines is suggested to contribute to metabolic and vascular changes that may increase the risk of dementia.[44] A standard lipid profile was conducted. Total cholesterol, low-density lipoprotein cholesterol (LDL), high-density lipoprotein cholesterol (HDL), and triglycerides were collected. High total cholesterol (> 200 mg/dL), high LDL (> 130 mg/dL), and low HDL (< 40 mg/dL) are associated with increased risk for CV disease.[45]

2.5.5 | Clinical markers of cardiometabolic disease

Resting heart rate, systolic blood pressure (SBP), and diastolic blood pressure (DBP) were measured with caregivers in a sitting position after 5 min of resting with no talking. Body mass index: height was measured on a standard stadiometer, without shoes, and recorded in centimeters. Weight was measured in kilograms using a calibrated scale with the participant in street clothing, without shoes. BMI was calculated by the formula BMI = weight in kilograms/(height in cm)^2. Waist-to-hip ratios (WHRs) were also collected.

2.5.6 | Sleep quality

Caregiver sleep quality was assessed using the Pittsburgh Sleep Quality Inventory (PSQI). The 19-item self-report examines sleep quality and disturbances over a 1-month period.[46] Participants respond on a four-point Likert scale that measures seven components of sleep. The PSQI score ranges from 0 to 21, with higher scores indicating worse sleep quality. A total score of less than 5 is generally considered to indicate good sleep quality, while a score of more than 5 is considered to indicate poor sleep quality. The PSQI has well-established validity and reliability with a Cronbach's alpha of 0.85.[46]

2.6 | Analysis

Only baseline questionnaire and biomarker data were included in the current analyses. All data were reviewed for data entry errors, normality assumptions, potential outliers, and missing data. Overall, missing data were low across study measures (< 5%), apart from salivary cortisol, which had 18.6% missing data. The missing data for salivary cortisol were primarily due to difficulties in sample collection. Missing data were assumed to be missing at random (MAR), and listwise deletion was used to handle missing values. While this approach reduced the sample size for analyses involving salivary cortisol, the low overall rate of missingness across other measures minimized its impact on the primary outcomes. Biomarker variables that did not meet normality assumptions were transformed using natural log (LN) logarithmic transformation. Descriptive statistics were run for all measures. For continuous variables, descriptive data were presented as mean ± standard deviation or median (interquartile range), based on normality assumptions. Pearson's correlations were run with total telomere length and age as outcomes.

We conducted linear regression analyses to test a series of a priori hypotheses derived from our conceptual model:

1. Greater perceived stress would be associated with worse psychological outcomes, including higher depressive symptoms, anxiety, caregiver burden, and poorer sleep quality.

2. Greater perceived stress would be associated with increased use of negative coping strategies (e.g., confrontive coping, escape avoidance) and lower use of positive coping strategies.
3. Greater perceived stress would be associated with shorter telomere length.
4. Shorter telomere length would be associated with elevated markers of cardiometabolic disease risk, including higher CAR, CRP, IL-6, insulin, and blood pressure, as well as greater WHR.

Each hypothesis was evaluated using a two-step modeling approach. First, we ran unadjusted linear regression models to estimate the strength of bivariate associations. Next, adjusted models included age, sex, and comorbidity burden (CCI) as covariates. These covariates were selected a priori based on their known influence on both psychological and physiologic outcomes in aging and caregiving populations and to maintain comparability across models. Perceived stress and telomere length were modeled as independent variables, depending on the hypothesis tested, and psychological, behavioral, and physiological measures were modeled as dependent variables. Group differences for categorical variables were tested using chi-square tests, and analysis of variance (ANOVA) was used for continuous variables across categories. All analyses were completed using SPSS 29. While our analytic plan was guided by theory and structured hypotheses, we acknowledge the breadth of outcomes reflects the exploratory nature of this secondary analysis and the multidimensional impact of chronic caregiving stress.

2.7 | Study outcomes

We identified two categories of study outcomes: (1) psychological and behavioral outcomes and (2) physiological outcomes reflecting cellular aging and cardiometabolic health. Primary outcomes included telomere length (as a marker of cellular aging); psychological health indicators such as depressive symptoms, anxiety symptoms, sleep quality, and caregiver burden; and cardiometabolic biomarkers, including CAR, CRP, IL-6, insulin, blood pressure, and WHR. Secondary outcomes included coping strategies, assessed using subscales of the WCQ, and additional biomarkers such as adiponectin, resistin, cholesterol subfractions, triglycerides, and glucose.

Analyses were structured around two main approaches. First, correlation analyses were conducted to examine bivariate relationships between age, telomere length, and other continuous variables. Second, a priori hypotheses were tested using linear regression models, in which perceived stress was modeled as the independent variable predicting psychological, behavioral, and physiological outcomes (Hypotheses 1–3), and telomere length was modeled as the independent variable predicting cardiometabolic and inflammatory risk (Hypothesis 4). All adjusted models included age, sex, and CCI score as covariates. Within the psychological domain, we conceptualized depression, anxiety, caregiver burden, and sleep quality as outcomes reflective of psychological stress and coping. While caregiver burden is often used as a predictor in other models, we treated it as an outcome variable to reflect its role as a key psychosocial consequence of sustained caregiving stress. Coping styles were analyzed separately as modifiable behavioral correlates of stress, not as primary outcomes. Cortisol and telomere length were included to capture complementary aspects of stress physiology. AR reflects dynamic neuroendocrine activity and is considered a biomarker of acute or daily stress regulation. In contrast, telomere length reflects cumulative cellular aging and long-term physiological wear and tear. Although both may be influenced by chronic stress, they operate on different biological timescales and were interpreted accordingly in the analysis and discussion.

3 | RESULTS

3.1 | Sample and participants

The sample consisted of 142 participants. Since we only had 118 DNA samples for telomere length analyses, we included those in the study. Family caregivers were 55 ± 10 years of age, mostly female (86%), and had college or postgraduate education (71%) (Table 1). Arthritis, depression, hypertension, diabetes, and human immunodeficiency virus (HIV) were the most identified comorbidities among the population (Table 1).

3.2 | Assessments of psychological stress

Descriptive statistics for psychological measures are presented in Table 2. Associations between perceived stress and outcome variables are presented as unadjusted models and models adjusting for age, sex, and comorbidities (Table 3). Perceived stress was positively associated with all three negative coping practices, including distancing ($\beta = 0.280$, $p = 0.003$), escape avoidance ($\beta = 0.249$, $p = 0.009$), and confrontive coping ($\beta = 0.202$, $p = 0.037$), with no associations with positive coping practices. Higher perceived stress was significantly associated with greater symptoms of anxiety ($\beta = 0.534$, $p < 0.001$) and depression ($\beta = 0.510$, $p < 0.001$), worse sleep quality ($\beta = 0.301$, $p = 0.002$), and measures indicative of increased caregiver strain ($\beta = 0.334$, $p < 0.001$). Furthermore, perceived stress was negatively associated with total telomere length ($\beta = -0.341$, $p < 0.001$).

3.3 | Assessments of physiologic stress

Descriptive statistics for physiologic measures are presented in Table 4. Associations between total telomere length and outcome variables are presented as unadjusted models and models adjusting for age, sex, and comorbidities (Table 5). Shorter total telomere length among caregivers was associated with measures indicative of poor cardiometabolic health. CAR ($\beta = -0.341$, $p < 0.001$), CRP ($\beta = -0.225$, $p = 0.009$), IL-6 ($\beta = -0.093$, $p = 0.300$), insulin ($\beta = -0.227$, $p = 0.009$), SBP ($\beta = -0.297$, $p = 0.001$), DBP ($\beta = -0.274$, $p = 0.001$), and WHR ($\beta = -0.153$, $p = 0.109$) were negatively associated with total telomere

TABLE 1 Caregiver sociodemographic and clinical characteristics.

Characteristic	Mean ± SD or *N* (%)
Age (years)	55 ± 10
Ethnicity	
Hispanic or Latino	3 (2.5)
Gender	
Female	98 (83)
Education	
High school	22 (19)
Technical/vocational	13 (11)
College	48 (41)
Post-graduate	31 (26)
Caregiving relationship	
Spouse	15 (13)
Child	48 (41)
Sibling	12 (10)
Other	39 (33)
Marital status	
Married	37 (31)
Single	37 (31)
Divorced/separated	33 (28)
Widowed	5 (4)
Caregiver health	
Systolic blood pressure (mmHg)	124.97 ± 15.9
Diastolic blood pressure (mmHg)	75.36 ± 8.0
Body mass index (kg/m^2)	30.71 ± 5.8
Waist-to-hip ratio	
Women	0.068 ± 0.007
Men	0.059 ± 0.013
Charlson Comorbidity Index	1.24 ± 2.1
Comorbidities	
Arthritis	27 (23)
Depression	25 (21)
Hypertension	19 (16)
Diabetes	14 (12)
HIV	13 (11)

Abbreviations: HIV, human immunodeficiency virus; SD, standard deviation.

TABLE 2 Stress, sleep, and psychological caregiver study measures.

Measure	Mean ± SD
Perceived Stress Scale	17.22 ± 6.9
Pittsburg Sleep Quality Index	8.58 ± 4.0
Center for Epidemiological Studies Depression Scale	13.26 ± 0.0
State Trait Anxiety Inventory	39.83 ± 12.82
Ways of Coping Questionnaire	
Confrontive Coping	5.54 ± 3.2
Distancing	5.89 ± 3.25
Self-Controlling	9.70 ± 4.1
Seeking Social Support	7.56 ± 4.6
Accepting Responsibility	3.68 ± 2.7
Escape Avoidance	6.17 ± 4.2
Planful Problem Solving	9.45 ± 3.5
Positive Reappraisal	12.26 ± 5.17
Zarit Burden Interview	
Total	38.95 ± 15.9
Personal Strain	19.96 ± 8.6
Role Strain	10.66 ± 5.3

length. PAI-1 ($\beta = 0.228$, $p = 0.011$), adiponectin ($\beta = 0.199$, $p = 0.026$), and resistin ($\beta = 0.166$, $p = 0.060$) were positively associated with total telomere length.

4 | DISCUSSION

This secondary analysis examined the relationship between perceived stress and markers of psychological and physiological resilience in Black family caregivers of persons with ADRD. Although prior studies have often examined psychological or biological outcomes in isolation,[47] integrating these domains is essential for understanding how chronic stress becomes biologically embedded and influences long-term health. This approach draws on established models of stress and coping and research linking stress to inflammation, cellular aging, and cardiometabolic risk. In populations facing cumulative disadvantage, such integration helps clarify how stress cascades across systems and contributes to disparities in health outcomes. Our findings build on this literature by linking perceived stress to accelerated cellular aging, elevated inflammation, poorer psychological health, and impaired cardiometabolic function.

Consistent with our first hypothesis, greater perceived stress was associated with worse psychological health, including elevated caregiver strain, more symptoms of anxiety and depression, and poorer sleep quality. Chronic sleep disturbances can contribute to mood impairment, metabolic dysfunction, and increased risk of hypertension and diabetes,[48] suggesting poorer sleep quality may be associated with other health outcomes affecting this population. These results align with caregiver studies using stress-coping models to assess responses to caregiving stressors.[49–51] Notably, how caregivers interpret their experience can shape how stress affects well-being, and some studies also highlight caregiving benefits.[13,52]

Caregivers who reported greater perceived stress also reported greater use of negative coping strategies (e.g., confrontive coping, escape avoidance). This supports the stress-coping framework suggesting that ineffective coping may contribute to or exacerbate anxiety and depressive symptoms among caregivers.[51]

TABLE 3 Adjusted and unadjusted effect size estimates for perceived stress and psychologic outcomes.

	Unadjusted[a]		Adjusted[b]	
Parameter	***β***	***p*-value**	***B***	***p*-value**
Perceived Stress Scale	−0.291	0.002	−0.255	0.004
Pittsburg Sleep Quality Index	0.308	0.001	0.301	0.002
State Trait Anxiety Index	0.508	<0.001	0.534	<0.001
Center for Epidemiologic Services—Depression	0.492	<0.001	0.510	<0.001
Ways of Coping Questionnaire				
Confrontive Coping	0.193	0.041	0.202	0.037
Distancing	−0.264.	0.005	0.280	0.003
Self-Controlling	0.186	0.050	−0.204	0.032
Seeking Social Support	−0.154	0.106	−0.150	0.115
Accepting Responsibility	−0.020	0.830	−0.001	0.988
Escape Avoidance	0.221	0.019	0.249	0.009
Planful Problem Solving	−0.041	0.668	−0.038	0.699
Positive Reappraisal	−0.126	0.186	−0.141	0.143
Zarit Burden Index				
Total	0.368	<0.001	0.334	<0.001
Personal Strain	0.375	<0.001	0.354	<0.001
Role Strain	0.292	0.002	0.260	0.005

[a]Linear regression model with no covariates.
[b]Linear regression model adjusted for age, gender, race, and Charlson Comorbidity Index.

TABLE 4 Physiologic caregiver study measures.

Measure	Mean ± SD Median (IQR)
Total telomere length (kb)	58.41 (59.0)
Cortisol awakening response (%)	34.03 (113.1)
C-reactive protein (mg/dL)	1.76 (3.2)
Interleukin-6 (mg/dL)	1.95 (1.5)
Insulin (mg/dL)	10.20 (6.8)
Plasminogen activator inhibitor-1 (mg/dL)	2.46 (2.8)
Adiponectin (mg/dL)	4154.54 (5281.5)
Resistin (mg/dL)	9.11 (8.4)
Total cholesterol (mg/dL)	178.34 ± 40.3
Low density lipoproteins (mg/dL)	111.65 ± 35.1
High density lipoproteins (mg/dL)	48.80 ± 12.8
Triglycerides (mg/dL)	85.13 ± 42.5
Glucose (mg/dL)	93.85 ± 25.0

Abbreviation: IQR, interquartile range.

Supporting our third hypothesis, higher perceived stress was linked to shorter telomere length. These findings align with biological models linking chronic stress to cortisol reactivity and telomere shortening.[21,53] Studies suggest that elevated cortisol exposure promotes oxidative stress, which directly contributes to telomere shortening and reduced telomerase activity.[54]

Our findings suggest HPA-axis hyperactivity, a factor implicated in stress-related disorders like depression, which may exacerbate health risks.[55] HPA-axis hyperactivity can impair immune function by downregulating glucocorticoid receptors in leukocytes, potentially increasing caregivers' susceptibility to chronic illness.[56,57] These interconnected mechanisms may explain our fourth hypothesis, where shorter telomeres were linked to cardiometabolic risk markers such as elevated CAR, CRP, insulin, and blood pressure. Telomere length and cortisol reflect different aspects of the stress response. Telomere length captures cumulative biological aging, while cortisol indicates short-term HPA axis activity and daily stress reactivity. Although both are influenced by chronic stress, they represent distinct biological processes and should not be interpreted interchangeably.

Contrary to our expectations, we found no significant association between telomere length and IL-6, adiponectin, resistin, or glucose. This suggests a nuanced relationship between cellular aging and vascular inflammatory pathways. The markers used in this study provide a snapshot of potential pathophysiological mechanisms that mediate the proatherogenic effects of chronic stress.[58]

Higher levels of IL-6 and CRP have been linked to a greater risk of cardiovascular disease.[42,59] This may reflect differences in biomarker sensitivity to chronic stress. Some studies suggest CRP may be a more reliable clinical indicator of chronic inflammation than IL-6, due to its longer half-life.[57,60] Other studies have shown that IL-6 and CRP may be correlated with reduced telomere length.[61] While our study found associations between perceived stress, telomere shortening,

TABLE 5 Adjusted and unadjusted effect size estimates for total telomere length and physiologic caregiver study measures.

	Unadjusted[a]		Adjusted[b]	
Parameter	***β***	***p*-value**	***β***	***p*-value**
Cortisol awakening response (%)	−0.394	<0.001	−0.341	<0.001
C-reactive protein (mg/dL)	−0.255	0.006	−0.225	0.009
Interleukin-6 (mg/dL)	−0.096	0.311	−0.093	0.300
Plasminogen activator inhibitor-1 (mg/dL)	0.253	0.006	0.203	0.027
Insulin (mg/dL)	−0.278	0.003	−0.185	0.035
Adiponectin (mg/dL)	0.220	0.018	−0.157	0.088
Resistin (mg/dL)	0.203	0.029	0.182	0.040
Systolic blood pressure (mmHg)	−0.388	<0.001	−0.297	0.001
Diastolic blood pressure (mmHg)	−0.285	0.002	−0.274	0.001
Waist-to-hip ratio	−0.267	0.003	−0.282	0.003
Total cholesterol (mg/dL)	−0.059	0.530	−0.039	0.655
Low density lipoproteins (mg/dL)	0.088	0.346	0.067	0.449
High density lipoproteins (mg/dL)	−0.152	0.102	−0.096	0.288
Triglycerides (mg/dL)	−0.064	0.493	−0.063	0.506
Glucose (mg/dL)	0.027	0.772	0.091	0.306
Heart rate (bpm)	0.103	0.268	−0.004	0.969
Body mass index (kg/m^2)	−0.025	0.786	−0.050	0.557

[a]Linear regression model with no covariates.
[b]Linear regression model adjusted for age, gender, race, and Charlson Comorbidity Index.

and inflammation, meta-analytic evidence suggests mixed evidence and small effects, thus challenging assumptions about the clinical significance of such markers.[52,62] More research is needed to better understand the relationship between inflammatory markers and cellular aging.

In this study, telomere length was positively associated with PAI-1 blood concentrations. This unexpected finding warrants further investigation, as it contrasts with prior studies showing that endothelial dysfunction is associated with telomere erosion in older adults.[63] Elevated PAI-1 levels, a marker of endothelial dysfunction, reflect chronic stress responses and are linked to coronary heart disease.[64,65] These findings suggest that Black dementia caregivers with shorter telomeres may be at greater risk for cellular senescence and vascular inflammation, contributing to elevated cardiometabolic disease risk.[66]

Additionally, we found that shorter telomeres were associated with higher blood pressure and WHR, though no significant associations were found for heart rate, BMI, or plasma lipids. While systolic blood pressure, diastolic blood pressure, and heart rate are well-established markers of cardiovascular health,[67] caregiver research frequently uses heart rate variability to assess cardiovascular health.[68] Multiple studies have found a relationship between heart rate variability and telomere length, which may explain our null findings for resting heart rate.[69,70]

Higher BMI is associated with an increased risk of cardiovascular diseases, but unlike WHR, it does not assess visceral fat distribution. Moreover, it is associated with increased risk of cardiovascular disease, diabetes, and metabolic syndrome.[71] WHR is often considered to be a better predictor of metabolic-related diseases, which may explain its closer association with cellular aging in our cohort.[72]

We originally hypothesized that shortened telomere length would be associated with decreased adiponectin and increased IL-6 and resistin levels. Existing literature suggests complex interaction between IL-6, resistin, and adiponectin, though the exact mechanisms continue to be investigated.[73] Our results indicate multiple pathways likely influence adiponectin secretion and their relationships with cellular aging, warranting further study.

Adipokines influence insulin sensitivity through distinct pathways. Adiponectin is inversely associated with adiposity, dyslipidemia, and insulin resistance, while pro-inflammatory cytokines like resistin show positive associations. Insulin resistance leads to elevated glucose, reduced insulin sensitivity, and impaired lipid metabolism, which may accelerate cellular aging.[74] In our study, telomere length was associated with insulin but not with glucose or plasma lipids, suggesting that different biological mechanisms may underlie these relationships or that some effects are not yet detectable.

Our findings suggest that Black family caregivers who experience chronic stress also experience poor sleep and greater symptoms of anxiety and depression. Considering our theoretical framework, this may be due to maladaptive coping strategies indicating poor psychosocial resiliency among this caregiving population. It is important to recognize that Black caregiving is carried out against a backdrop of systemic factors (structural racism and other social determinants of health)

that may, de facto, place them at a consistently higher level of stress than NHW caregivers, so that the stress of caregiving may be additive to their other life stressors. Additionally, family caregivers who had reduced telomere length also had poor cardiometabolic health outcomes, which may be due to dysregulation of the parasympathetic and sympathetic nervous systems. Together these findings highlight a need to consider the interplay of psychosocial stress, cellular aging, and resiliency in ADRD caregiving in the Black American community.

This study extends existing research by integrating psychological, behavioral, and physiological outcomes within a unified stress-coping framework among Black dementia family caregivers, a population underrepresented in biomarker studies. By modeling perceived stress, coping, sleep, mood, inflammation, and cellular aging together, our findings offer a more comprehensive view of how chronic stress manifests biologically. The exclusive focus on Black caregivers highlights the need to consider how systemic racism and community disadvantage shape caregiving experiences and health. Future work can build on this foundation to examine additional contextual factors, including intergenerational caregiving and access to resources, to further inform culturally specific models of caregiving stress and health inequity.

4.1 | Limitations

While this study offers important insights into the effects of chronic stress among Black ADRD caregivers, several limitations should be noted. Given the breadth of outcomes examined, analyses were exploratory and intended to identify broad patterns of association. Future work should employ targeted designs and advanced modeling (e.g., mediation, structural equation modeling) to clarify underlying mechanisms. This secondary analysis did not assess key physiological systems such as the renin-angiotensin system, autonomic nervous system, or HPA axis in detail, important pathways implicated in chronic stress. The sedentary inclusion criteria may limit generalizability, particularly among healthier or more active caregivers, and participants may have had underlying health conditions. Medication was not accounted for and may confound inflammatory outcomes. Although the majority-female sample reflects broader caregiving trends, the requirement of high caregiving intensity may exclude those experiencing lower but still significant stress. Future studies should consider caregiving intensity alongside contextual factors such as socioeconomic status, caregiving duration, and care recipient symptoms to better capture diverse health impacts. In sum, these limitations underscore the complexity of ADRD caregiving research and the need for improved methods.

5 | CONCLUSION

This study found that perceived stress was associated with a measure indicative of cellular aging, inflammation, and poor cardiometabolic health in Black family caregivers of individuals living with Alzheimer's disease and related dementias. Elevated stress was also associated with shortened telomere length, higher levels of depressive and anxiety symptoms, and worse sleep. Furthermore, stress was associated with negative coping with no association with positive coping. Drawing on the life-course health development and stress and coping frameworks, we found that caregivers reporting greater levels of stress had lower levels of biopsychosocial resilience.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest. Author disclosures are available in the supporting information.

CONSENT STATEMENT

Participants were informed about the study's purpose, procedures, potential risks and benefits, and confidentiality measures. Written informed consent was obtained from all participants (or their legal guardians) prior to their participation. Participants were informed that they could withdraw from the study at any time without penalty.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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