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Diabetes stress and health: Is aging a strength or a vulnerability?

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Abstract The purpose of this work was to examine (1) relations of diabetes stress to psychological well-being and health, (2) links of age to such outcomes and (3) the extent to which age moderated relations from diabetes stress to outcomes. These aims were addressed in a diverse community sample of 207 individuals recently diagnosed with type 2 diabetes, employing survey and daily diary methods. Participants reported age, diabetes distress, and psychological distress at baseline and 6 months later. Glycemic control also was assessed. Participants completed a 14-day daily diary protocol in which they reported daily diabetes stressors, mood, and self-care. Both cross-sectional and longitudinal results showed diabetes distress was associated with poorer outcomes. Daily diary data showed that individuals who reported more daily diabetes stressors reported poorer outcomes. Older age was linked to less psychological distress, but was unrelated to daily diabetes stressors. Older age attenuated relations of diabetes distress to outcomes.

Keywords Diabetes · Stress · Aging

Introduction

Diabetes is one of the most prevalent chronic diseases in the United States and is the 7th leading cause of death. It is estimated that 30.3 million people in the United States have diabetes, and the vast majority of these people (90–95%) have type 2 diabetes (Centers for Disease Control and Prevention, 2017a). Type 2 diabetes has increased dramatically in the United States over the past few decades. Since 1960, the percentage of adults in the United States with diagnosed diabetes has increased by a factor of 10 (Centers for Disease Control and Prevention, 2017b). Complications from diabetes include heart disease, stroke, kidney disease, and lower limb amputation (Centers for Disease Control and Prevention, 2017a).

Type 2 diabetes occurs when the body's cells are no longer able to use the insulin secreted from the pancreas effectively, a process termed "insulin resistance." Management of type 2 diabetes typically consists of diet or weight management, exercise, and taking medication. Self-management is far from optimal (see Gonzalez et al., 2015, for a review). Executing these behaviors every day for the rest of one's life is time-consuming, complicated, costly, and—not surprisingly—stressful. In fact, levels of diabetes distress are higher than levels of depression among adults with type 2 diabetes (Gonzalez et al., 2015). Chronic stress related to diabetes is related to poor self-care behavior and poor glycemic control (Hilliard et al., 2016; Tanenbaum et al., 2013). Diabetes stress has been shown to be a stronger predictor of poor glycemic control than depression (Fisher et al., 2010). Thus, the first aim of the present study is to examine the relation of diabetes stress to psychological and physical health, employing a multi-method approach in a cohort of persons recently diagnosed with type 2 diabetes.

Although most individuals are diagnosed with type 2 diabetes between the ages of 45 and 64, type 2 diabetes can be diagnosed in childhood, young adulthood, and older adulthood (Centers for Disease Control and Prevention, 2017a). In other words, type 2 diabetes extends across the lifespan. However, it is unclear how age is related to diabetes stress and psychological well-being. Theories of development address the relation of age to well-being and stress in general but do not focus on chronic illness or diabetes specifically.

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For example, Socioemotional Selectivity Theory suggests that older adults experience enhanced psychological well-being and overall less stress because they emphasize the present and prioritize meaningful relationships (English & Carstensen, 2016). However, it is not clear whether older age is associated with enhanced psychological well-being in the context of a chronic stressor, type 2 diabetes.

It also is not clear how age is associated with the stress of managing diabetes. One study showed older age was associated with less diabetes distress (Hessler et al., 2011). Consistent with this finding, research on aging suggests that older adults cope better with stress and show less reactivity to stress because their past experiences in coping with stress have led to better emotion regulation strategies (Berg & Upchurch, 2007; Charles, 2010). However, the Strength and Vulnerability Model argues that older age is not only associated with strengths but also with vulnerabilities (Charles, 2010). Strengths appear when confronted with stressors that benefit from the emotion regulation strategies of reappraisal, minimization, and avoidance—stressors that are likely to be acute and controllable; vulnerabilities appear when confronted with major stressors that are chronic and uncontrollable because these emotion regulation strategies are not as effective.

In the context of coping with a newly diagnosed chronic disease, such as type 2 diabetes, which is chronic but not uncontrollable, predictions about the relations of age to stress are not clear. Prior research and theory on the benefits of aging in the face of stress confound age with experience. That is, older adults are likely to have faced the chronic stressor for a longer period of time. In this study, however, we examine diabetes stress in the context of a wide age range of adults who were recently diagnosed with diabetes, thus removing the confound between age and length of disease. If the benefits of aging are due to having coped with a stressor for a longer period of time, we should not find a benefit of aging in the present sample. Predictions also are uncertain because it is unclear if diabetes is a stressor that benefits from the emotion regulation strategies that are more common in older adulthood. The emotion regulation strategies that older adults use to manage stress—positive reappraisal and avoidance—are strategies that may serve to reduce psychological distress but may not enhance diabetes outcomes such as self-care behavior and glycemic control. Because previous research in the area of diabetes is more likely to control for age than examine age explicitly, a second aim of the present study is to examine the link of age to diabetes stress, independent of length of disease.

The developmental literature also has shown that age moderates the relation of stress to psychological well-being, such that relations are attenuated for older adults. This hypothesis has been tested in stressor reactivity studies, which typically focus on the relation between a general stressor and affect via daily diary or ecological momentary assessment (EMA). In an examination of this association across seven daily diary or EMA studies, the authors concluded that older age was generally associated with less stress reactivity to everyday stressors (Stawski et al., 2019). However, the interaction between age and stress was only statistically significant in two of the seven studies. One 30-day daily diary study of adults ages 18–89 showed that age was associated with less reactivity to stressor pileup (i.e., the accumulation of stressors) but not to reactivity to the current daily stressor (Schilling & Diehl, 2014). To our knowledge, a daily diary or EMA design has not evaluated this hypothesis in the context of type 2 diabetes. However, a community sample of adults with type 2 diabetes showed that age moderated the relation of a survey measure of diabetes distress to glycemic control, such that diabetes distress was related to poor glycemic control for younger but not older adults even when time since diagnosis was statistically controlled (Hessler et al., 2011). Thus, the third aim of the present study is to examine whether age moderates the relation of overall diabetes stress to well-being as well as the relation of daily experiences of diabetes stressors to daily well-being.

Thus, the present study had three goals. First, we examined the relation of diabetes stress to psychological distress and diabetes outcomes, hypothesizing that diabetes stress would be associated with poor outcomes consistent with previous research. Second, we examined the relation of age to diabetes stress, psychological distress, and diabetes outcomes. Although older adults report less stress in general, we did not make a directional prediction in regard to diabetes stress or diabetes outcomes because it is unclear if this link extends to the stress associated with managing diabetes. Third, we examined whether age altered the relation of diabetes stress to psychological distress and diabetes outcomes. We examined these last two questions among people who varied in age but were recently diagnosed with type 2 diabetes so that we could disentangle age from length of illness.

We addressed each of these questions in the context of a community sample that was recruited for a larger study that examined the effects of communal coping (i.e., perceiving a stressor as shared and collaboration with a partner to manage it; Helgeson et al., 2018) on relationship, behavioral, and psychological health outcomes (see Helgeson et al., in press for additional study details). This community sample spanned the age range of adulthood and was diverse in terms of gender, race, education, and income. Because secondary aims of the larger study were to examine effects attributable to sex and race, there were fairly equal numbers of male and female patients and White and Black patients. We expanded on previous research by using a multi-method approach. We employed a survey measure of diabetes distress and examined its relation to psychological distress and

diabetes outcomes cross-sectionally and longitudinally over 6 months. We also conducted a 14-day daily diary study to examine the relation of daily diabetes stress to daily mood and diabetes outcomes.

Method

Participants

Participants were 207 persons who had been recently diagnosed with Type 2 diabetes and were currently living with or married to a romantic partner. Patients were 55% male; 53% White and 47% Black. Age ranged from 25 to 82 ($M = 53$). The average time since diagnosis was less than 2 years; in fact, 65% of the sample was diagnosed within the past 2 years. Half of the sample had incomes that ranged between $30,000 and $80,000. Eleven percent (11%) of the sample had incomes less than $20,000, and 12% had incomes that exceeded $100,0000. Complete demographic information is shown in Table 1.

Recruitment

Patients were recruited from the community (i.e., health fairs, mass media advertising, brochures in physician offices). In order to oversample African Americans, we targeted churches and health fairs located in the African American community. Interested persons contacted the research team by phone and were screened for eligibility. To be eligible, patients had to have been diagnosed with type 2 diabetes within the past 5 years, not have another illness that affected their daily life more than diabetes (e.g., cancer), have a partner who did not have diabetes, and be married or cohabiting with their partner in a marital-type relationship for at least 2 years.

Of the 658 people who contacted us, the majority ($n = 419$) were ineligible because they reported being diagnosed more than 5 years ago. Of the remaining 239, 22 refused after screening, 4 refused before eligibility could be determined, and 3 were determined to be ineligible after signing the consent form but before completing the protocol (1 couple was not romantically involved; in 2 couples, both persons had diabetes). Of the 210 couples who completed the study, three were dropped from analyses (1 couple was intoxicated during the study, 1 couple was not romantically involved, 1 participant had type 1 diabetes instead of type 2 diabetes).

Although being diagnosed less than 5 years ago was an eligibility requirement, participants referred themselves to the study, and diagnosis date was obtained from physicians after informed consent and study procedures had been completed. Of the 207 patients in this report, we later learned 11 had been diagnosed between 5 and 8 years ago (6 between 5–6 years ago). Because removal of these persons did not alter the results, we retained the full sample of 207 couples.

Table 1 Demographics of the sample ($n = 207$ patients)

Sex	55% male	45% female
Race	53% white	47% black
Age	Mean = 53.17	SD = 11.11
Education	less high school	3.86%
	High school grad	27.54%
	Some college	17.39%
	2-year college	25.12%
	4-year college	13.04%
	Postgrad	12.56%
	Missing[a]	.05%
Work status	55.97% yes	
Income	Median range	$40–$59,000
Relationship length (years)	Mean = 18.14	SD = 13.91
Years since diagnosis	Mean = 1.88	SD = 1.68
Body mass index	Mean = 33.65	SD = 6.98
Medication	None	8.21%
	Oral only	66.18%
	Insulin	10.14%
	Oral + Insulin	15.46%
HbA1c	Mean = 7.19	SD 1.80

[a]One person is missing because they refused to answer the question

Procedure

The study received Institutional Review Board approval from Carnegie Mellon University and the University of Pittsburgh Couples were met by two research assistants in either their homes (71.5%) or at the university research laboratory with mileage reimbursement (28.5%). The procedure consisted of an in-person structured interview (Time 1) and a 14-day daily diary protocol. Prior to the start of any study procedures, informed consent was obtained from both individuals included in the study. Each couple member was interviewed separately in a private room. During the in-person interview, patients completed measures of diabetes distress, psychological health, and self-care behavior. Instruments were administered aloud to reduce participant burden (given the wide range of education, some participants are likely to have had difficulty reading all of these questions), allow participants the opportunity to ask questions, and make the interview more enjoyable for participants. At the end of the interview, body mass index was assessed with the Tanita Body Composition Analyzer SC-240 and a stadiometer for height. HbA1c was assessed with the DCA Vantage Analyzer. Then, participants were presented with an iPad to complete a brief questionnaire at the end of the day for

14 consecutive days. This questionnaire assessed diabetes-related stress, mood, and self-care behaviors.

Six months later (Time 2), participants were interviewed again and completed the same survey measures of psychological distress and self-care behavior. HbA1c was again assessed. Participants were paid for each portion of the study. At Time 2, we retained 97% of the sample ($n = 200$).

Survey measures

Demographic information

We assessed sex, race/ethnicity, age, whether participants were currently working (yes, no), how many years they had been married or living together, and whether the participants were taking oral medication and/or insulin for their diabetes. We measured education with the categories shown in Table 1. For family income, respondents were asked to choose which category best reflected their family income. The first category was less than $20,000; subsequent categories were in $10,000 increments with the last category being over $100,000. Multiple imputation was used for 15 missing values due to respondent preference not to answer this question.

Diabetes distress

We administered the 5-item diabetes regimen distress subscale from the Diabetes Distress Scale at Time 1 (Polonsky et al., 2005). Although the instrument contains four sources of diabetes distress, the strongest correlate of poor self-care is regimen distress (Fisher et al., 2015; Polonsky et al., 2005). Participants indicate the extent to which each item is a problem for them on a 6-point scale, ranging from 1 (not a problem) to 6 (a very serious problem). The internal consistency was high ($\alpha = .86$).

Psychological distress

Psychological distress was measured with three instruments at Time 1 and Time 2. We measured depressive symptoms with the 20-item Center for Epidemiological Studies Depression Scale (CESD; Radloff, 1977). Each item is rated on a 0 (rarely or none of the time) to 3 (all of the time, 5–7 days) scale (Time 1 $\alpha = .91$; Time 2 $\alpha = .92$). We administered the Satisfaction with Life Scale (Diener, et al., 1985), which asks participants to indicate how much they agree or disagree with 5 statements on a 1–7 scale (Time 1 $\alpha = .86$; Time 2 $\alpha = .85$). Finally, we used the 4-item abbreviated version of the Perceived Stress Scale (Cohen, et al., 1983), which asks participants how often they felt or behaved a certain way on a scale ranging from 0 (never) to 4 (very often; Time 1 $\alpha = .79$; Time 2 $\alpha = .78$). Because these three scales were strongly intercorrelated (*r's* ranged from .62 to .71), we reverse-scored life satisfaction and took the average to form a psychological distress index at Time 1 and Time 2.

Diabetes self-efficacy

The self-efficacy subscale of the Multidimensional Diabetes Questionnaire (Talbot, et al., 1997) was administered at Time 1 ($\alpha = .86$) and Time 2 ($\alpha = .88$). This scale consisted of 7 items, and ratings were made on a scale from 0% to 100%, reflecting how confident patients felt that they could do various aspects of diabetes self-care (e.g., "How confident are you in your ability to follow your diet?", "How confident are you in your ability to keep your blood sugar level under control?").

Diabetes self-care

We measured self-care behavior with the Summary of Diabetes Self-Care Activities (Toobert & Glasgow, 1994), which assesses the primary domains of diabetes self-care: diet (5 items), exercise (3 items), blood glucose checking (2 items), medication adherence (2 items). Internal consistencies of multi-item scales and correlation coefficients for two-items scales were good: diet (Time 1 $\alpha = .72$; Time 2 $\alpha = .75$); exercise (Time 1 $\alpha = .80$; Time 2 $\alpha = .81$), blood glucose checking (Time 1 $r = .79$; Time 2 $r = .68$); medication adherence (Time 1 $r = .61$; $r = .25$). Among the patients taking diabetes medication (85% of the sample), we also measured medication adherence with the four-item Medication Adherence Index (e.g., "Do you ever forget to take your medication?" [reverse-coded]; Morisky, et al., 1986; Time 1 $\alpha = .71$; Time 2 $\alpha = .76$). Higher scores reflect greater adherence.

Glycemic control

Glycemic control was measured with the DCA Vantage Analyzer during each in-person interview.

Daily diary measures

Daily diabetes stress

Each day participants were asked to identify what was most bothersome about dealing with diabetes that day. They either briefly described what the event was or had the option to say "nothing." The first author reviewed a random sample of responses to identify the categories. When saturation was reached, 12 distinct categories were identified: felt physically sick, fatigue, food/diet, too much to do, exercise, blood glucose checking, high/low blood sugar readings, insulin problems, taking oral medication, foot problems, sleep

problems, or other. Two independent research assistants coded the responses into one of 12 categories. Inter-rater reliability was high (kappa = .92).

Daily mood

Patients were asked to rate 12 items on a 5-point scale, ranging from 1 "not at all" to 5 "a lot of the time" regarding how often they felt each mood state during the course of the day. Variance component analysis for daily diary data was used to examine scale reliability (Bolger & Laurenceau, 2013). Three items measured depressed mood (sad, depressed, unhappy; α = .79), three items measured happy mood (happy, pleased, cheerful; α = .78) three items measured angry mood (angry, annoyed, mad; α = .81), and three items measured anxious mood (anxious, nervous, calm; α = .59). Because the anxious mood scale had poor reliability, we dropped the "calm" item to improve reliability. The coefficient of anxious predicting nervous was strong (coefficient = .46, $p < .001$). The anger items were developed for this study; the remainder of the items were taken from the Profile for Mood States (Usala & Hertzog, 1989).

Daily self-care

Patients were asked three face valid questions regarding diabetes self-care: (1) how much did you follow your diet today? (1 = not at all, 5 = very much); (2) Did you exercise today? (no, yes); (3) Did you take your medication today? (no, yes). Brief measures were used to reduce participant burden and encourage patients to complete all of the daily questionnaires. Patients completed an average of 12.5 of the 14 daily diaries.

Overview of the analyses

We examined the relation of demographic and disease-variables to the survey measure of diabetes distress as well as the daily measure of diabetes stress to identify the relevant statistical control variables. These analyses necessarily included age; thus, we examined the relation of age to diabetes distress, psychological health, and diabetes outcomes. Prior to hypothesis testing, we also present descriptive statistics on the survey measure of diabetes distress and daily diary measure of diabetes stress.

The first set of analyses focused on the survey measure of diabetes regimen distress. We examined its relation to psychological distress and self-care behavior concurrently with regression analyses. We entered relevant statistical control variables on the first step, age and regimen distress on the second step, and the interaction of age with regimen distress on the third step of the equation. When the interaction with age was not significant, we removed it from the final step of the equation. Next, we employed the same procedure to examine whether Time 1 regimen distress predicted Time 2 outcomes, but added statistical controls for the respective Time 1 outcome.

The second set of analyses focused on the daily measure of diabetes stress. We used multi-level modeling to address this question. Daily stress is a Level 1 variable, whereas age and relevant statistical control variables were Level 2 variables. Each analysis included the relevant statistical control variables, daily diabetes stress, age, and the cross-level age by diabetes stress interaction to predict each of the three mood and three self-care outcomes. We computed the within and between-subjects effects for daily diabetes stress to distinguish between effects that are attributable to variations across days (i.e., within-subjects) from effects that are attributable to variations between persons (i.e., between-subjects; Bolger & Laurenceau, 2013).

Results

Background analyses

Of the variables shown in Table 1, sex, relationship length, and body mass index (BMI) were related to greater diabetes distress. There was a non-significant trend indicating that females reported more diabetes distress ($M = 2.91$, SE = .13) than males ($M = 2.61$, SE = .14), $F(1, 205) = 2.66$, $p = .10$; $\eta^2 = .01$. Participants who had been in the relationship for a longer period of time reported less diabetes distress, $r = -.19$, $p < .01$, and people with a higher body mass index reported greater diabetes distress, $r = .20$, $p < .01$. For the daily measure of stress, race (white more; coefficient = −.11; SE = .05, $p < .05$), greater education (coefficient = .03, SE = .02, $p < .05$), and higher income (coefficient = .02, SE = .01, $p < .05$) were associated with more stress. Medication regimen was not related to either the survey measure or the daily measure of diabetes stress, but was related to age, such that people on insulin were younger ($M = 50.15$, $SD = 10.44$) than people not on insulin ($M = 54.21$, $SD = 11.18$), $t(205) = 2.32$, $p < .05$. Length of diabetes was not related to diabetes distress or the daily measure of diabetes stress. Thus, we statistically controlled for sex, race, education, relationship length, BMI, and whether or not the patient was on insulin (or not) in all analyses.

Because age was a focus of our analyses, we examined its relation to diabetes distress and outcomes. Age was related to the survey measure of regimen distress, such that younger people reported more distress, $r = -.28$, $p < .001$. Age also was related to each of the survey outcome variables. Older age was related to lower psychological distress, $r = -.34$, $p < .001$; higher self-efficacy, $r = .27$, $p < .001$; better self-care behavior, $r = .23$, $p < .01$; higher levels of medication

adherence, $r = .28$, $p < .001$; and better glycemic control, $r = -.20$, $p < .01$. Age was not related to the daily measure of diabetes stress. Importantly, age was unrelated to length of disease, $r = -.01$, $p = .85$.

We also compared participants who dropped out of the study at Time 2 to those who remained in the study on demographic and baseline variables. There were no differences on any of these variables with the exception of age, self-care behavior, and glycemic control. Those who dropped out of the study were younger, $t\ (205) = -1.99$, $p < .05$, had poorer self-care behavior, $t\ (205) = -2.35$, $p < .05$, and poorer glycemic control at baseline, $t\ (205) - 3.49$, $p < .001$.

Descriptives on diabetes distress

The average level of diabetes regimen distress was 2.74 ($SD = 1.34$), indicating a moderate amount of distress. This survey measure of regimen distress was modestly related to an aggregate of the daily diabetes stress measure, $r = .25$, $p < .001$, indicating that people's self-reports of general regimen distress is related to the amount of diabetes stress they experienced in a 2-week period.

In the daily diary portion of the protocol, participants reported a diabetes stressor on 38% of the days. The nature of the stressor was primarily diet. Not only was diet identified in 54% of the cases, the next most frequent categories of stressor accounted for less than 10% of the stressors: blood glucose checking (8%) and the experience of high and low blood sugars (7%).

Predicting survey outcomes

As shown in Table 2, diabetes regimen distress was related to greater psychological distress, lower self-efficacy, poorer self-care behavior, lower medication adherence, and worse glycemic control. Age interacted with regimen distress to predict self-efficacy and medication adherence. As shown in Fig. 1, the relation of regimen distress to reduced self-efficacy was stronger for younger than older adults. As shown in Fig. 2, the relation of regimen distress to lower medication adherence was stronger for younger than older people.

We also examined whether regimen distress predicted changes in outcomes over 6 months by controlling for the baseline level of the outcome. As shown in Table 3, greater regimen distress predicted an increase in psychological distress, a decline in self-efficacy, a decline in self-care, and a decline in medication adherence over the next 6 months. Regimen distress did not predict changes in HbA1c. There were no interactions of regimen distress with age in predicting changes in outcomes over 6 months.

Predicting daily outcomes

As shown in Table 4, within-subjects daily diabetes stress was not significantly related to daily mood. There was a nonsignificant relation of daily diabetes stress with depressed affect ($p < .10$), such that days with a diabetes stressor were associated with more depressed affect. Of the three self-care outcomes, within-subjects daily diabetes stress was related to poorer daily dietary adherence but not to daily exercise or medication adherence. Thus, days in which participants reported a diabetes stressor were associated with poorer dietary adherence on that particular day.

Between-subjects daily stress was related to happy mood, depressed mood, anxious mood, and medication adherence on a daily basis, such that people who reported more diabetes stressors were more likely to report less happy mood, more depressed mood, more anxious mood, and lower medication adherence on a daily basis compared to people who reported fewer diabetes stressors. In addition, between-subjects diabetes stress interacted with age to predict daily depressed affect and daily anxious affect. As shown in Fig. 3, the relation of diabetes stress to more depressed affect was

Table 2 Age and regimen distress prediction of time 1 outcomes: multiple regression coefficients (standard errors)

	Psychological distress	Self-efficacy	Self-care behavior	Medication adherence	HbA1c
Sex	− .06 (.10)	.25 (2.05)	− .03 (.06)	.11 (.08)	− .26 (.23)
Race	.27* (.11)	− 2.76 (2.28)	− .17* (.07)	− .23* (.09)	.51* (.26)
Education	− .08* (.04)	− .13 (.71)	.03 (.02)	.04 (.03)	− .08 (.08)
Rel length	.00 (.00)	− .01 (.01)	.00 (.00)	.00 (.00)	− .00 (.00)
BMI	.00 (.01)	− .40* (.15)	− .01* (.01)	.00 (.01)	− .02 (.02)
Insulin	.21+ (.12)	1.32 (2.42)	.18* (.07)	.09 (.09)	1.09*** (.27)
Age	− .01+ (.01)	.07 (.12)	− .00 (.00)	.01 (.01)	− .01 (.01)
Regimen	.30*** (.04)	− 9.92*** (.80)	− .26*** (.02)	− .18*** (.03)	.23** (.09)
Age × Regimen	–	.17* (.07)	–	.01* (.00)	–

BMI body mass index, *Rel length* relationship length, *Regimen* regimen distress

*$p < .05$; **$p < .01$; ***$p < .001$

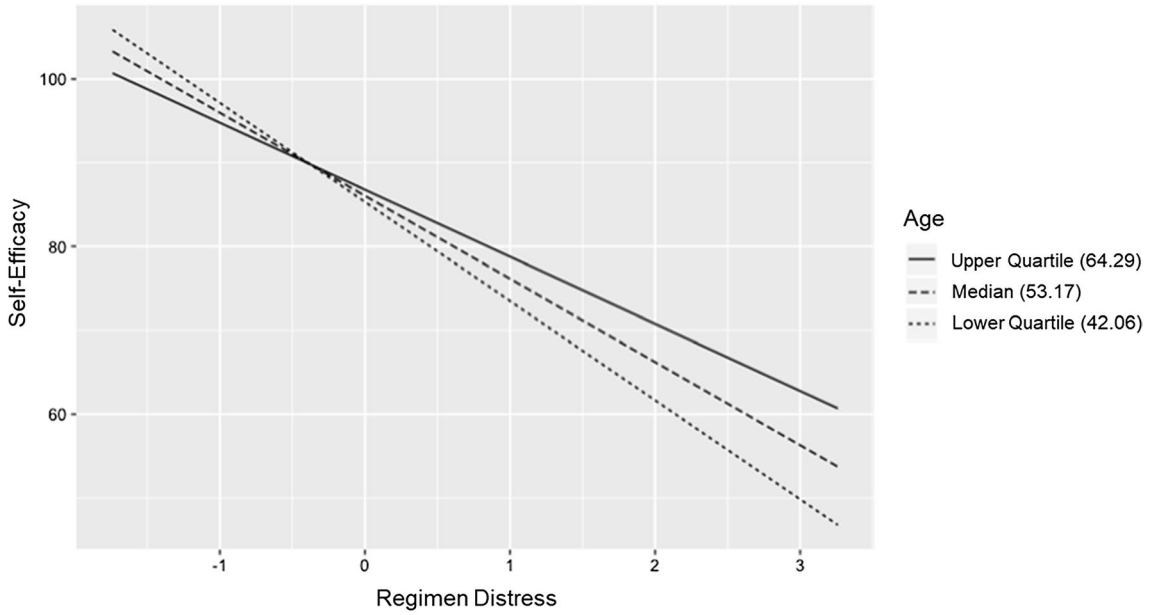

Fig. 1 The relation of regimen distress to lower self-efficacy is stronger for younger than older adults

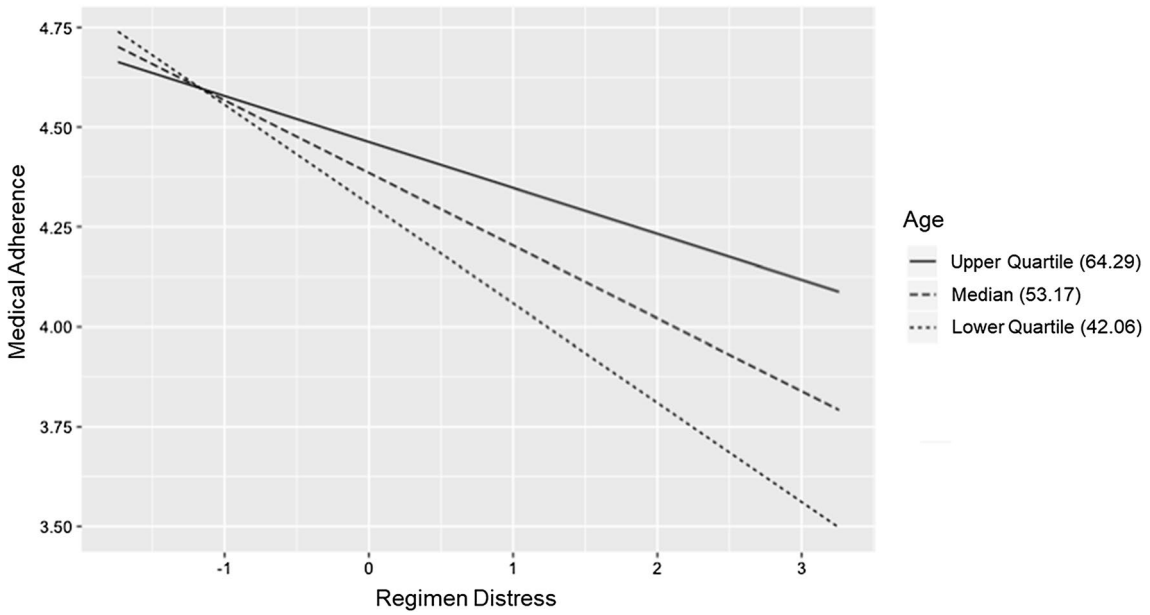

Fig. 2 The relation of regimen distress to lower medication adherence is stronger for younger than older adults

attenuated for older adults. Similar findings are shown in Fig. 4 with regard to anxious mood.

Discussion

In a diverse community sample of adults recently diagnosed with type 2 diabetes, diabetes stress—specifically the stress associated with taking care of diabetes—was associated with poor psychological and diabetes outcomes, consistent with past research (Gonzalez et al., 2015; Hilliard et al., 2016; Tanenbaum et al., 2013). Diabetes stress was associated with higher psychological distress and poor self-care behavior whether it was measured in terms of a survey measure of distress or a daily measure of a specific stressor occurrence.

Importantly, some of these relations held over time. That is, participants' reports of regimen distress after having been relatively recently diagnosed with diabetes were associated

Table 3 Age and regimen distress prediction of time 2 outcomes: multiple regression coefficients (standard errors)

	Psychological distress	Self-efficacy	Self-care behavior	Medication adherence	HbA1c
Time 1	.74*** (.05)	.41*** (.08)	.58*** (.07)	.64*** (.07)	.65*** (.05)
Sex	.16* (.07)	1.39 (2.23)	.04 (.06)	− .08 (.08)	− .30+ (.16)
Race	− .03 (.08)	7.85** (2.48)	.05 (.07)	.02 (.08)	.13 (.18)
Education	− .00 (.03)	.94 (.76)	− .01 (.02)	.05+ (.03)	− .01 (.06)
Rel Length	.00 (.00)	.01 (.01)	.00 (.00)	.00 (.00)	.00 (.00)
BMI	− .01* (.01)	.01 (.17)	.01 (.01)	.00 (.01)	.01 (.01)
Insulin	− .04 (.09)	1.62 (2.62)	.15* (.07)	.05 (.08)	− .03 (.20)
Age	.01* (.00)	− .01 (.13)	− .01 (.00)	.01 (.01)	− .01 (.01)
Regimen	.09** (.03)	− 5.79*** (1.15)	− .08* (.03)	− .07* (.03)	.02 (.06)
Age × regimen	–	–	–	–	–

BMI body mass index, *Rel length* relationship length, *Regimen* regimen distress

+$p < .10$; *$p < .05$; **$p < .01$; ***$p < .001$

Table 4 Daily diabetes stressor predicting daily outcomes: multilevel models with coefficients (standard errors)

	Happy	Anger	Depressed	Anxiety	Exercise	Diet	Medication
Time	.00 (.00)	− .01** (.00)	− .01 (.00)	− .01** (.00)	− .07 (.28)	− .01+ (.00)	− .00* (.00)
Age	.02** (.01)	− .01** (.00)	− .01+ (.00)	− .01 (.00)	.49+ (.29)	.01+ (.01)	− .00 (.00)
Race	− .02 (.13)	− .15+ (.08)	− .12 (.09)	− .16 (.10)	− 8.54 (6.82)	− .17 (.13)	− .04 (.05)
Education	.02 (.04)	− .01 (.03)	.01 (.03)	.01 (.03)	3.33 (2.19)	.05 (.04)	− .01 (.02)
Income	.01 (.01)	− .02 (.01)	− .04** (.01)	− .05** (.02)	− 2.70* (1.15)	.03 (.02)	.02+ (.01)
BMI	− .00 (.01)	.00 (.01)	.01 (.01)	.01 (.01)	− .29 (.46)	− .02* (.01)	− .00 (.00)
Insulin	.06 (.13)	.03 (.09)	.01 (.10)	− .07 (.10)	6.08 (7.18)	.15 (.14)	.15** (.05)
WS stressor	.02 (.04)	.03 (.04)	.07+ (.04)	.02 (.04)	− 2.54 (2.65)	− .28*** (.05)	− .01 (.01)
BS stressor	− .52** (.18)	.13 (.11)	.33** (.12)	.44** (.14)	− 4.59 (9.43)	− .28 (.18)	− .19** (.07)
WS stressor X age	–	–	.00 (.00)	.00 (.00)	–	–	
BS stressor X age	–	–	− .02* (.01)	− .03** (.01)	–	–	

WS within subjects, *BS* between subjects

+$p < .10$; *$p < .05$; **$p < .01$; ***$p < .001$

with an increase in psychological distress, a reduction in self-efficacy, and a decline in self-care behavior over 6 months. Thus, the effects of diabetes stress are not limited to the immediate timeframe, but have the potential to influence behavior over the coming months. These findings suggest that clinicians should consider engaging their patients in conversations about how they handle diabetes tasks and about actions they can take to reduce the stress associated with taking care of diabetes. Given that the most frequently identified daily stressor was diet, these conversations necessarily should focus on the stress surrounding food—selection of food, preparation of food, food choice in restaurants, and ways to reduce calories.

The use of a daily diary methodology to test the associations of daily stress to daily health outcomes was a study strength. However, the daily diary findings were largely limited to between-subjects effects. Thus, across two different methodologies, we found that people who face more regimen stress or report more diabetes stressors on a daily basis are the ones who report greater psychological distress and have poorer diabetes outcomes. We did not find any evidence that within-subjects changes in the experience of a diabetes stressor on a daily basis were associated with changes in health outcomes on that particular day—with the exception of dietary adherence. Because daily stressors most notably revolved around diet difficulties, the link of daily stress to poorer dietary adherence on a given day is not surprising. The lack of within-subjects effects may be due to our fairly crude assessment of a diabetes stressor. We simply asked people to identify whether or not they had experienced a diabetes stressor. Throughout the daily diary protocol, we used simple and abbreviated measures to enhance compliance and make the procedure less burdensome. However, we may have learned more about daily diabetes stress if we had assessed the magnitude of the stressor, the controllability of the stressor, or even asked participants how troublesome

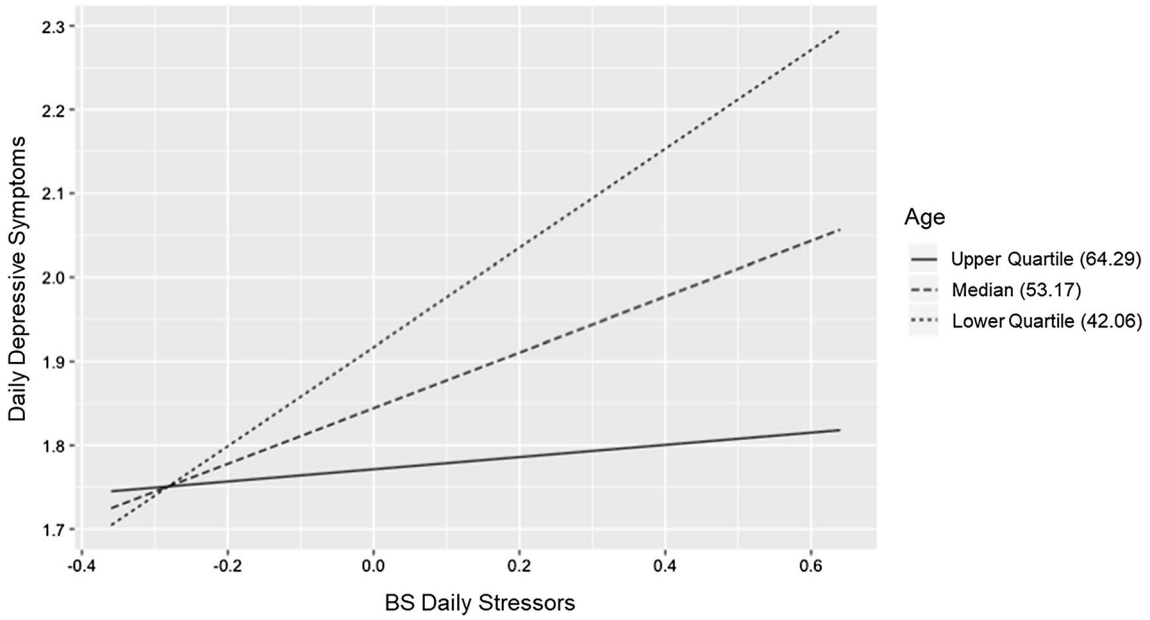

Fig. 3 The relation of Between Subjects (BS) daily stressors to higher daily depressed mood is stronger for younger than older adults

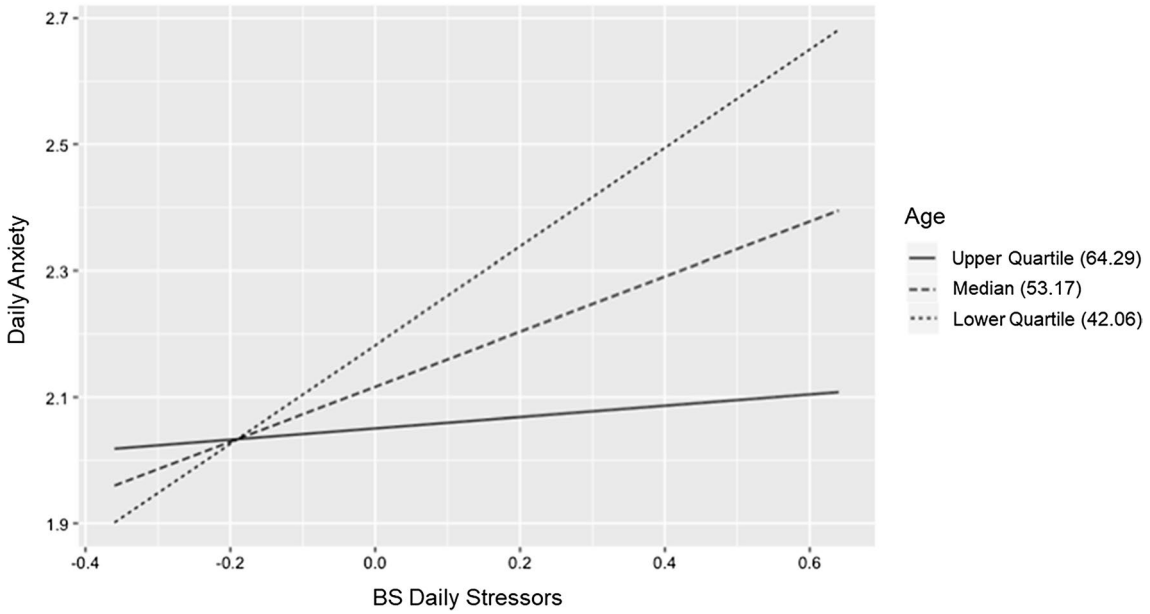

Fig. 4 The relation of Between Subjects (BS) daily stressors to higher daily anxious mood is stronger for younger than older adults

they found the particular stressor. Thus, our lack of within-subjects effects may be attributed to the lack of sensitivity of our stress measure.

Our second study goal was to examine the relation of age to diabetes stress. Although previous research has shown that older adults report less stress and are less bothered by the same stressors compared to younger adults (e.g., English & Carstensen, 2016), it was unclear to us whether such findings would generalize to diabetes and to the context of a sample where length of disease was held constant. Older adults reported less regimen distress than younger adults, but age was unrelated to reports of a daily stressor. It has been theorized that older adults have more effective emotion regulation strategies to handle stressors (Berg & Upchurch, 2007; Charles, 2010), which may explain the current pattern of findings. Older adults may experience the same number of daily stressors, but they may engage in more effective emotion regulation strategies—such as reappraisal—that

may reduce their overall perception and report of regimen distress. It also is possible that older adults have more resources to deal with chronic illness compared to younger adults because chronic illness is more common among older adults. That is, older adults are more likely to have peers with chronic illness, who may be sources of both emotional and informational support. Future research should test each of these possibilities. For all of these reasons, it is not surprising that older adults reported less psychological distress, consistent with previous research. Older adults also reported better diabetes outcomes—higher self-efficacy and better self-care—which likely explains why older adults had better glycemic control.

We found evidence that age moderated the association of diabetes stress to psychological and diabetes outcomes across both methodologies. In each case, the relation of diabetes stress to outcomes was attenuated for older adults, suggesting that older adults were less reactive to diabetes stress. These findings are consistent with Socioemotional Selectivity Theory (Carstensen et al., 2011; English & Carstensen, 2016), which hypothesizes older adults show less stress reactivity. The findings also are consistent with the Strength and Vulnerability model (Charles, 2010), which suggests older adults show less reactivity to stressors for which their emotion regulation skills may be particularly well-suited. Older adults are thought to have better emotion regulation strategies, partly because they have had more experience coping with stress. Interestingly, these findings show that older adults are more resilient in the face of a stressor that is equally novel to them as it is to younger adults.

Although it is unclear whether type 2 diabetes is a stressor that can be addressed effectively with older individuals' emotion regulation strategies, the present findings suggest this may be the case. The emotion regulation strategy that is most likely to be helpful in the context of diabetes is positive reappraisal. Positive reappraisal is a strategy that can be used to reduce the threat associated with diabetes and make the disease seem more manageable. Another common emotion regulation strategy of older individuals to reduce distress is avoidance. However, avoidance of diabetes stressors would not be beneficial in the context of disease management. The fact that the relation of stress to self-efficacy and medication adherence was reduced for older adults suggests that they are not capitalizing on avoidance as an emotion regulation strategy. Future research should aim to identify the specific coping strategies younger and older adults are using to manage diabetes to see if emotion regulation explains why older adults are less reactive to diabetes stress.

While this study disentangles the effect of age and length of diagnosis in a diverse sample of adults with type 2 diabetes, this work also has its limitations. First, we did not measure emotion regulation strategies such as reappraisal and avoidance. While existing theories posit that older adults engage in more effective emotion regulation strategies that increase well-being, we are unable to empirically test this explanation of the relations observed among age, diabetes stress, and adjustment outcomes. Second, it is possible that younger individuals experience more distress because diagnosis of type 2 diabetes at their age is less normative. Younger individuals may experience more regimen distress because they are aware they will face these regimen difficulties for years to come. Finally, as previously mentioned, the daily survey measure was limited in that it simply asked whether individuals experienced a diabetes stressor and what that stressor was. Future research should collect information on the severity, controllability, and burden of the stressor. This would allow researchers to test whether older adults are more reactive to stressors when they are more severe or uncontrollable, or whether we would continue to see benefits of age.

In sum, the present study expands on previous research by replicating the relation of diabetes stress to higher psychological distress and poor diabetes outcomes in a racially and economically diverse sample. This study extends previous research by utilizing two different methodologies and by employing a longitudinal design that showed diabetes stress is related to deterioration in outcomes over time. Finally, the study shows that the relation of diabetes stress to psychological and behavioral outcomes is attenuated in older adults, even when age is disentangled from length of stressor (in this case, diabetes). That is, even when older adults have no more experience in coping with a particular stressor than younger adults, older adults show less reactivity to stress.

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Compliance with ethical standards

Conflict of interest Vicki S. Helgeson, Meredith Van Vleet, Melissa Zajdel declare that they have no conflict of interest.

Human and animal rights and informed consent All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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