Examining the Relationship Between Delay Discounting, Delay Aversion, Diabetes Self-care Behaviors, and Diabetes Outcomes in U.S. Adults With Type 2 Diabetes

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OBJECTIVE

Delay discounting and delay aversion are emerging areas for understanding diabetes management; however, few data exist on their relationship with multiple diabetes self-care behaviors and diabetes outcomes.

RESEARCH DESIGN AND METHODS

This cross-sectional study included 356 adults with type 2 diabetes across three racial/ethnic groups receiving care from two primary care clinics. The primary predictors were delay discounting and delay aversion. Outcomes included self-care behaviors, quality of life (QOL; mental health component score [MCS], physical component score), and A1C. Multiple linear regression models were run to examine the association between predictors and the outcomes, A1C, QOL, and each self-care behavior.

RESULTS

Higher delay discounting was associated with lower engagement in self-care behaviors for general diet (B = −0.06; 95% CI −0.12; −0.01), specific diet (B = −0.07; 95% CI −0.12; −0.03), and foot care (B = −0.10; 95% CI −0.17; −0.02). Higher delay aversion was associated with lower engagement in self-care behaviors for general diet (B = −0.06; 95% CI −0.10; −0.01), specific diet (B = −0.03; 95% CI −0.07; −0.01), foot care (B = −0.11; 95% CI −0.17; −0.05), and lower MCS (B = −0.38; 95% CI −0.71; −0.06).

CONCLUSIONS

In a diverse sample of adults with type 2 diabetes, higher delay discounting and higher delay aversion were significantly related to lower engagement in self-care behaviors. High delay aversion was specifically related to lower QOL. These findings offer new knowledge by highlighting the role that delay-related behaviors may have in the performance of self-care behaviors and the impact on QOL. Work is needed to further elucidate these relationships. Specifically, these results highlight the importance of targeting value and decision-making for diabetes self-management.

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Diabetes affects 13% of U.S. adults age ≥18 years and remains the seventh leading cause of death in the United States (1). Diabetes is associated with major comorbid conditions such as cardiovascular disease and kidney disease, and individuals with diabetes experience hospitalizations at higher rates and increased cost compared with those without diabetes (1,2). Racial/ethnic minorities experience an even greater burden of disease and have higher prevalence, higher risk of complications, and higher mortality rates compared with non-Hispanic Whites with diabetes (1). National recommendations show that engagement in seven self-care behaviors can significantly reduce individual and societal burden of diabetes (3). These include regular glucose monitoring, eating a healthful diet, engaging in physical activity, taking medication as prescribed, problem solving and coping, and reducing risk of diabetes complications (3). However, despite existing evidence, engagement in self-care behaviors remains low (1,4).

Evidence suggests several factors that contribute to low engagement in self-care behaviors for diabetes management. These include factors at the individual level, such knowledge, skills, and competing demands (5–9); factors at the community level, such as environmental barriers, and limited availability of healthy foods and green space for physical activity (10); and factors at the health systems level, such as provider communication and access to and availability of services (11,12). When present, these factors create complex barriers to engagement in self-care behaviors for individuals living with diabetes. Lifestyle interventions to address the complex barriers that occur across these multiple levels show that engagement in self-care behaviors can increase, resulting in improved diabetes-related outcomes. However, sustaining self-care behaviors over time remains a challenge (13–15), suggesting factors that have not yet been accounted for may be influencing long-term engagement of self-care behaviors.

Evidence suggests that delay-related behavior, the process of making choices that result in immediate outcomes or rewards versus choosing to wait for a greater, more meaningful outcome, is a critical factor that may affect long-term engagement in performing diabetes self-care behaviors (16,17). Drawn from behavioral economics, the decision-making process underlying delay-related behavior involves two key constructs: *1*) delay discounting and *2*) delay aversion. Delay discounting relates to the perceived value placed on an outcome, which may be influenced by the time it takes to achieve that outcome (18,19). For example, value may be placed on the health benefits of following a nutritious diet; however, when delay is experienced in actualizing the health benefit, decrement in value may occur as the delay persists (18,19). Characterized as high delay discounting (i.e., devaluing the future and placing greater emphasis on outcomes that are immediately attainable) leads to value-based decision-making. Delay aversion varies from delay discounting by placing emphasis on the emotional response as a consequence of delay, for example, experiencing negative emotional responses when experiencing a delay, leading to the avoidance of delays due to negative emotional responses (20).

The literature on delay-related behavior suggests that delay discounting and aversion are transdisease processes that have primarily been examined across health behaviors such as obesity (21) and engagement in high-risk behaviors such as substance use (22–25). More recently, delay discounting has been examined within populations with prediabetes and type 2 diabetes, and although some evidence shows that delay discounting is related to glycemic control (16,17,26), most studies have included homogenous populations and have not examined the role of delay discounting and delay aversion in patients with type 2 diabetes.

From a patient-centered approach, understanding value-based decisions that underlie diabetes self-management and the role of delay-related behavior will be critical for tailoring care plans that will maximize self-management strategies at the patient level. However, several questions remain unanswered that warrant additional investigation to elucidate the role of delay-related behavior on diabetes management. Specifically, few data exist on the relationship between delay discounting and multiple diabetes self-care behaviors, and even less is known about the role of delay aversion in the performance of diabetes self-care behaviors. In addition, existing evidence for delay-related behavior in type 2 diabetes has been developed primarily outside of the United States, within non-Hispanic White populations, limiting the generalizability to U.S. adults with type 2 diabetes. Therefore, the overarching aim of this study was to identify independent factors associated with delay-related behavior (specifically, delay discounting and delay aversion) among adults with type 2 diabetes in the United States and to examine the relationship between delay discounting, delay aversion, diabetes self-care behaviors, and clinical outcomes. We hypothesized that sociodemographic factors would be significant independent factors associated with delay-related behavior and that delay-related behavior would be significantly related to diabetes self-care behaviors and clinical outcomes.

RESEARCH DESIGN AND METHODS

Design, Sample, and Setting

This cross-sectional study included a sample of 356 adults age ≥18 years with type 2 diabetes. Participants were recruited from two primary care clinics at two academic medical centers in the southeastern United States. Study inclusion criteria consisted of being ≥18 years of age and having a clinical diagnosis of type 2 diabetes. Participants were approached in the clinic waiting areas and asked if they were interested in participating. Those who indicated they would like to participate were then taken to a private location and underwent informed-consent procedures and were formally screened for inclusion. Once participants were consented, each participant completed a paper-based survey with the research assistant. Diabetes diagnosis was confirmed from the medical record. All procedures performed were in accordance with the ethical standards of the Institutional Review Board of the Medical University of South Carolina and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Measures

Sample characteristics include age, sex, race/ethnicity, marital status, educational level, hours worked per week, annual income level, health insurance, health status, recruitment site, and diabetes duration. Age, education, hours worked per week, health status, and diabetes duration were treated as continuous variables, and mean with SD were

reported for each. Sex was categorized as either male or female. Race/ethnicity was reported as non-Hispanic White, Non-Hispanic Black, and Hispanic/other. Marital status was listed as either married or not married. Annual income level was categorized as US$0–$9,999, $10,000–$19,999, $20,000–$34,999, and ≥$35,000. Health insurance was divided into three groups: no insurance, private insurance, and government insurance. Recruitment sites included an academic medical center and a Veterans Affairs medical center. Patients' A1C level was retrieved from the medical record and only patients who had an A1C value from a blood sample within the past 6 months from the date of the survey completion were included.

Primary Independent Variable

Delay-related behavior, the independent variable in this study, was measured on the Quick Delay Questionnaire (QDQ) (18). The QDQ is a 10-item, self-report scale that measures delay-related behavior in adults on two subscales: 5 items measure delay discounting and 5 items measure delay aversion (18). Scores are calculated separately for each subscale; higher scores indicate higher delay discounting (i.e., less value is placed on the future) and higher delay aversion (i.e., negative emotions when a delay is experienced).

Outcome Variables

The study outcomes included A1C; self-care behaviors, including general and specific diet, exercise, blood glucose testing, foot care, and quality of life (QOL); both the physical component score (PCS) and mental component score (MCS). The A1C from the prior 6 months was retrieved from the patient medical record at the time of survey completion. Diabetes self-care behaviors were measured using the Summary of Diabetes Self-care Activities (SDSCA) scale. The SDSCA is an 11-item scale that assesses the frequency of engagement across four self-care behaviors: diet, physical activity, blood glucose testing, and foot care (27). Quality of life was measured using the 12-Item Short-Form Survey (SF-12) (28). The SF-12 is a well-established generic measure of health status that assesses QOL across two domains, the PCS and the MCS. The PCS includes measures of *1*) functioning: the ability to perform moderate physical activities; *2*) role-physical: physical limitations; *3*) bodily pain: activities not being carried out due to pain; and *4*) general self-rated health. The MCS includes the following measures: *1*) vitality: energy; *2*) social functioning: social time; *3*) role-emotional: not focused on tasks due to emotional problems or not accomplishing what was desired; and *4*) mental health: feeling peaceful or blue and sad. Each component produces a continuous summary score, with higher scores indicating better QOL (28).

Statistical Analyses

Power calculations conducted before the study indicated that a sample size of 356 was sufficient to maintain 80% power for the multivariate analyses. Specifically, the sample size is sufficient to detect a change of at least 10% in R^2 for the primary independent variables (delay discounting and delay aversion) in their relationship on A1C, self-care, and QOL over and above the contribution of the covariates. As defined by Cohen (29), this is sufficient power to detect between a small effect and moderate effect (between 2% and 13% of the variance). Percentages and means were calculated for sample characteristics, and data were evaluated to ensure assumptions of linear regression were met; specifically, we tested for normality and variance. Interactions were run for delay discounting and race, and delay aversion and race. Interactions were not statistically significant, so final models were not stratified. Unadjusted mean values for delay discounting and delay aversion by demographic characteristics were calculated using one-way ANOVA, then we ran a linear regression model to assess the association between demographic characteristics and the independent predictors, delay discounting and delay aversion. Multiple linear regression models were run to examine the association between delay discounting and the outcomes, A1C, QOL, and each self-care behavior and delay aversion and the outcomes. All analyses were run using Stata, version 16.

Data and Resource Availability

Data used for this study are available upon reasonable request from the corresponding author.

RESULTS

Scale validation showed good internal consistency based on the Cronbach α for each subscale in our population, with α values of 0.59 for delay discounting subscale and 0.80 for delay aversion subscale, which are consistent with the psychometrics of the original scale (18) and suggest that the QDQ scale measures both constructs of delay discounting and delay aversion in this diabetes population.

Sample Characteristics

Table 1 lists the sample characteristics. Mean age of the sample population was 61.8 years. The majority of participants were male (70.1%), and 50.2% of the population was not married. Approximately 54.5% of participants were Black, 41.8% were White, and 3.7% were Hispanic/other. Participants, on average, had 12.9 years of education, and average diabetes duration for the sample was 11.5 years.

Independent Factors Associated With Delay-Related Behavior

Table 2 lists the independent factors associated with delay discounting and delay aversion. For delay discounting, the factor years of education was statistically significantly related to lower discounting scores (B = −0.24; 95% CI −0.38; −0.98), consistent with those who have more years of education placing greater value on the future. Similarly, for delay aversion, years of education was statistically significantly related to lower delay aversion (B = −0.26; 95% CI −0.45; −0.07), consistent with those with more years of education experiencing less averse emotions when a delay is present. Health status was marginally significant with lower delay aversion (B = −0.63; 95% CI −1.27; 0.01), suggesting that having higher reported health status may be associated with experiencing less averse emotions when a delay is present.

Multiple Linear Model for Association Between Delay-Related Behavior and Outcomes

Table 3 lists the multiple linear model results for the association between delay discounting, A1C, self-care behaviors, and QOL (PCS and MCS). In the unadjusted model (data not shown), delay discounting was negatively associated with general diet (B = −0.06; 95% CI −0.12; −0.01), specific diet (B = −0.06; 95% CI −0.11; −0.02), foot care (B = −0.07; 95% CI −0.14; −0.01), and MCS (B = −0.42; 95% CI −0.81; −0.03). After adjusting for sample characteristics, delay discounting

Table 1—Sample demographics

Sample (N = 356)	Percentage or mean (SD)
Age, years	61.8 (10.2)
Years of education	12.9 (3.1)
Hours worked per week	10.8 (18.8)
Health status[a]	2.5 (0.8)
Diabetes duration, years	11.5 (9.1)
Site	
Academic medical center	47.1
Veterans Affairs medical center	52.8
Sex	
Female	29.8
Male	70.1
Marital status	
Not married	50.2
Married	49.7
Race/ethnicity	
White	41.8
Black	54.5
Hispanic/other	3.7
Insurance status	
None	13.1
Private	20.7
Government	66.2
Annual income, USD	
0–9,999	19.4
10,000–19,999	26.4
20,000–34,999	21.5
≥35,000	32.8

[a]Health status range: 1 = poor to 5 = excellent.

remained negatively associated with general diet (B = −0.06; 95% CI −0.12; −0.01), as well as specific diet (B = −0.07; 95% CI −0.12; −0.03), and foot care (B = −0.10; 95% CI −0.17; −0.02). The relationship between delay discounting and MCS lost statistical significance after adjustment.

Table 2—Independent factors associated with delay discounting and delay aversion

Sample characteristic	Delay discounting B (95% CI)	Delay aversion B (95% CI)
Age	−0.01 (−0.05; 0.04)	−0.03 (−0.09; 0.03)
Years of education	−0.24 (−0.38; −0.98)**	−0.26 (−0.45; −0.07)**
Hours worked per week	−0.01 (−0.03; 0.02)	−0.01 (−0.04; 0.02)
Health status	−0.08 (−0.57; 0.41)	−0.63 (−1.27; 0.01)‖
Diabetes duration	−0.02 (−0.07; 0.02)	−0.02 (−0.08; 0.04)
Veterans Affairs medical center site	0.69 (−0.33; 1.71)	0.61 (−0.72; 1.95)
Male sex	0.62 (−0.46; 1.69)	0.66 (−0.74; 2.08)
Married	0.49 (−0.39; 1.38)	0.62 (−0.54; 1.78)
Race/ethnicity		
Black	−0.41 (−1.33; 0.50)	−0.72 (−1.93; 0.48)
Hispanic/other	0.63 (−1.53; 2.79)	−1.94 (−4.76; 0.88)
Insurance		
Private	0.39 (−1.13; 1.92)	0.80 (−1.20; 2.81)
Government	0.53 (−0.73; 1.79)	0.57 (−1.10; 2.23)
Income, USD		
10,000–19,999	0.27 (−1.02; 1.56)	0.56 (−1.13; 2.26)
20,000–34,999	0.12 (−1.33; 1.57)	0.92 (−0.99; 2.83)
≥35,000	−0.73 (−2.24; 0.77)	0.82 (−1.16; 2.79)

Reference groups: academic medical center site, female sex, not married, White race, no insurance, income <$10,000. B, unstandardized β coefficient. Statistically significant at **$P < 0.01$, ‖$P = 0.054$.

Table 4 shows the multiple linear model for the association between delay aversion, A1C, self-care behaviors, and QOL. In the unadjusted model (data not shown), delay aversion was negatively associated with general diet (B = −0.06; 95% CI −0.10; −0.02), specific diet (B = −0.03; 95% CI −0.07; −0.01), exercise (B = −0.05; 95% CI −0.10; −0.01), foot care (B = −0.10; 95% CI −0.15; −0.05), and MCS (B = −0.42; 95% CI −0.71; −0.12). After adjusting for sample characteristics, delay aversion remained negatively associated with general diet (B = −0.06; 95% CI −0.10; −0.01), specific diet (B = −0.03; 95% CI −0.07; −0.01), foot care (B = −0.11; 95% CI −0.16; −0.05), and MCS (B = −0.38; 95% CI −0.71; −0.06).

CONCLUSIONS

Overall, in this diverse sample of adults with type 2 diabetes, delay discounting and delay aversion were both inversely related to sociodemographic factors, self-care behaviors, and QOL, consistent with the hypotheses. Specifically, delay discounting was negatively associated with years of education, such that discounting the future was associated with fewer years of education. Delay aversion was also negatively associated with years of education. These associations are consistent with the literature for delay-related behavior showing that lower level of education is associated with higher discounting rates and placing less value on the future (30). Delay aversion was also marginally significant with health status, suggesting that those with lower health status may experience more negative emotions when delays are present.

In the multiple linear regression model, when controlling for sample characteristics, delay discounting was significantly related to lower engagement in self-care behaviors for general diet, specific diet, and foot care. When examining self-care behaviors by delay aversion, delay aversion was significantly related to lower engagement in self-care behaviors for general diet, specific diet, and foot care. Delay aversion was also related to lower scores for MCS QOL. These results suggest that individuals who place less value on the future and those who experience a negative emotional response when delays are present have lower engagement in self-care behaviors for diet and foot care. In addition, those

Table 3—Adjusted association among delay discounting, A1C, self-care, and quality of life

Sample characteristic	A1C B (95% CI)	General diet B (95% CI)	Specific diet B (95% CI)	Exercise B (95% CI)	Blood glucose testing B (95% CI)	Foot care B (95% CI)	PCS B (95% CI)	MCS B (95% CI)
Delay discounting	−0.01 (−0.05; 0.04)	−0.06* (−0.12; −0.01)	−0.07** (−0.12; −0.03)	−0.01 (−0.07; 0.05)	−0.05 (−0.13; 0.02)	−0.10** (−0.17; −0.02)	0.08 (−0.30; 0.46)	−0.37 (−081; 0.07)
Age	−0.03** (−0.05; −0.01)	0.02 (−0.01; 0.04)	0.01 (−0.01; 0.02)	0.01 (−0.02; 0.04)	0.01 (−0.02; 0.05)	0.02 (−0.01; 0.05)	0.11 (−0.06; 0.28)	0.15 (−0.05; 0.34)
Years of education	0.02 (−0.05; 0.08)	0.05 (−0.03; 0.13)	−0.01 (−0.07; 0.06)	0.06 (−0.02; 0.15)	−0.04 (−0.14; 0.06)	−0.11* (−0.21; −0.01)	−0.06 (−0.46; 0.34)	−0.15 (−0.61; 0.31)
Hours worked per week	0.01 (−0.01; 0.01)	−0.01 (−0.02; 0.01)	−0.01 (−0.02; 0.01)	−0.01 (−0.02; 0.01)	−0.01 (−0.02; 0.01)	−0.01 (−0.02; 0.01)	0.01 (−0.10; 0.11)	−0.03 (−0.15; 0.09)
Health status	0.01 (−0.23; 0.23)	0.20 (−0.05; 0.46)	0.13 (−0.07; 0.33)	0.62*** (0.33; 0.92)	−0.24 (−0.59; 0.10)	0.14 (−0.17; 0.46)	3.98*** (2.28; 5.68)	1.72 (−0.22; 3.65)
Diabetes duration	0.04*** (0.01; 0.05)	−0.01 (−0.03; 0.01)	−0.01 (−0.03; 0.01)	−0.01 (−0.04; 0.02)	0.06*** (0.03; 0.09)	0.02 (−0.01; 0.05)	−0.09 (−0.23; 0.05)	0.11 (−0.05; 0.26)
VA medical center	−0.03 (−0.50; 0.45)	−0.12 (−0.66; 0.41)	0.19 (−0.23; 0.61)	0.01 (−0.59; 0.62)	0.29 (−0.42; 1.01)	0.23 (−0.43; 0.89)	0.94 (−2.65; 4.54)	−2.99 (−7.08; 1.09)
Male sex	0.17 (−0.33; 0.66)	0.26 (−0.30; 0.82)	−0.30 (−0.74; 0.14)	0.22 (−0.42; 0.86)	−0.12 (−0.87; 0.64)	−0.27 (−0.97; 0.42)	−0.21 (−3.78; 3.36)	3.67 (−0.38; 7.73)
Married	−0.03 (−0.44; 0.37)	−0.08 (−0.54; 0.38)	−0.02 (−0.38; 0.35)	−0.14 (−0.66; 0.39)	0.33 (−0.29; 0.95)	−0.03 (−0.60; 0.54)	1.02 (−1.78; 3.82)	−1.56 (−4.74; 1.62)
Race/ethnicity								
Black	0.24 (−0.18; 0.66)	−0.02 (−0.51; 0.45)	0.23 (−0.15; 0.60)	0.50 (−0.04; 1.04)	0.10 (−0.54; 0.75)	0.41 (−0.18; 1.00)	3.4* (0.74; 6.09)	0.72 (−2.31; 3.76)
Hispanic/other	−0.06 (−1.03; 0.92)	0.55 (−0.57; 1.67)	0.91* (0.03; 7.79)	0.64 (−0.63; 1.92)	−0.27 (−1.79; 1.24)	0.11 (−1.28; 1.49)	2.01 (−5.44; 9.46)	11.80** (3.33; 20.27)
Insurance								
Private	0.05 (−0.65; 0.74)	−0.25 (−1.04; 0.55)	−0.15 (−0.78; 0.47)	−0.23 (−1.13; 0.67)	0.30 (−0.77; 1.37)	0.26 (−0.72; 1.24)	2.54 (−2.06; 7.14)	−3.07 (−8.31; 2.14)
Government	0.21 (−0.37; 0.79)	−0.20 (−0.86; 0.45)	0.12 (−0.39; 0.64)	−0.29 (−1.04; 0.45)	0.78 (−0.10; 1.67)	0.75 (−0.06; 1.56)	1.48 (−2.47; 5.44)	−2.40 (−6.89; 2.09)
Income, USD								
10,000–19,999	−0.05 (−0.64; 0.54)	−0.32 (−0.98; 0.35)	0.16 (−0.36; 0.69)	−0.46 (−1.22; 0.30)	0.26 (−0.64; 1.17)	0.11 (−0.72; 0.94)	1.14 (−2.48; 4.78)	−0.35 (−4.47; 3.77)
20,000–34,999	0.63 (−0.03; 1.29)	−0.32 (−1.07; 0.44)	0.29 (−0.29; 0.89)	−0.52 (−1.38; 0.33)	−0.21 (−1.24; 0.81)	−0.08 (−1.01; 0.86)	−2.42 (−6.62; 1.78)	1.03 (−3.74; 5.80)
≥35,000	0.24 (−0.45; 0.93)	−0.23 (−1.01; 0.56)	0.28 (−0.33; 0.91)	−0.84 (−1.74; 0.05)	−0.41 (−1.47; 0.65)	−0.11 (−1.08; 0.86)	−1.04 (−5.25; 3.16)	1.11 (−3.66; 5.88)

Reference groups: academic medical center site, female sex, not married, White race, no insurance, income <$10,000. B, unstandardized β coefficient; VA, Veterans Affairs. Statistically significant at *$P < 0.05$, **$P < 0.01$, and ***$P < 0.001$.

Table 4—Adjusted association among delay aversion, A1C, self-care, and quality of life

Sample characteristic	A1C B (95% CI)	General diet B (95% CI)	Specific diet B (95% CI)	Exercise B (95% CI)	Blood glucose testing B (95% CI)	Foot care B (95% CI)	PCS B (95% CI)	MCS B (95% CI)
Delay aversion	−0.01 (−0.05; 0.03)	−0.06* (−0.10; −0.01)	−0.03* (−0.07; −0.01)	−0.03 (−0.08; 0.02)	−0.04 (−0.10; 0.02)	−0.11*** (−0.16; −0.05)	0.14 (−0.15; 0.43)	−0.38* (−0.71; −0.06)
Age	−0.03** (−0.05; −0.01)	0.02 (−0.01; 0.04)	0.01 (−0.01; 0.02)	0.01 (−0.01; 0.04)	0.01 (−0.02; 0.05)	0.01 (−0.01; 0.04)	0.08 (−0.09; 0.26)	0.15 (−0.05; 0.35)
Years of education	0.02 (−0.05; 0.08)	0.05 (−0.02; 0.13)	0.01 (−0.06; 0.06)	0.06 (−0.02; 0.14)	−0.04 (−0.14; 0.07)	−0.11* (−0.21; −0.02)	−0.04 (−0.43; 0.34)	−0.14 (−0.58; 0.31)
Hours worked per week	0.01 (−0.01; 0.01)	−0.01 (−0.02; 0.01)	−0.01 (−0.02; 0.01)	−0.01 (−0.01; 0.01)	−0.01 (−0.03; 0.01)	−0.01 (−0.02; 0.01)	0.01 (−0.09; 0.12)	−0.04 (−0.17; 0.08)
Health status	−0.01 (−0.24; 0.21)	0.17 (−0.09; 0.42)	0.12 (−0.08; 0.33)	0.60*** (0.31; 0.89)	−0.23 (−0.62; 0.08)	0.08 (−0.23; 0.39)	3.96*** (2.26; 5.66)	1.74 (−0.17; 3.66)
Diabetes duration	0.03*** (0.01; 0.06)	−0.01 (−0.03; 0.01)	−0.01 (−0.03; 0.01)	−0.01 (−0.04; 0.01)	0.07*** (0.03; 0.09)	0.02 (−0.01; 0.05)	−0.09 (−0.22; 0.05)	0.11 (−0.04; 0.26)
VA medical center	−0.03 (−0.51; 0.44)	−0.13 (−0.66; 0.40)	0.16 (−0.26; 0.58)	0.03 (−0.57; 0.63)	0.24 (−0.48; 0.96)	0.25 (−0.39; 0.90)	0.83 (−2.78; 4.45)	−2.54 (−6.62; 1.53)
Male sex	0.15 (−0.33; 0.64)	0.29 (−0.27; 0.85)	−0.32 (−0.76; 0.13)	0.30 (−0.33; 0.93)	−0.08 (−0.84; 0.68)	−0.25 (−0.94; 0.43)	−0.60 (−4.24; 3.03)	3.92 (−0.17; 8.02)
Married	0.01 (−0.39; 0.40)	−0.05 (−0.51; 0.41)	−0.05 (−0.41; 0.32)	−0.10 (−0.62; 0.42)	0.31 (−0.32; 0.93)	0.01 (−0.56; 0.57)	0.69 (−2.12; 3.51)	−1.00 (−4.17; 2.17)
Race/ethnicity								
Black	0.21 (−0.21; 0.63)	−0.01 (−0.48; 0.47)	0.22 (−0.16; 0.60)	0.56* (0.02; 1.09)	0.04 (−0.61; 0.69)	0.44 (−0.15; 1.02)	3.20* (0.53; 5.88)	0.94 (−2.08; 3.95)
Hispanic/other	−0.05 (−1.02; 0.92)	0.44 (−0.67; 1.56)	0.77 (−0.12; 1.66)	0.65 (−0.62; 1.91)	−0.41 (−1.94; 1.11)	−0.12 (−1.49; 1.25)	1.65 (−5.84; 9.15)	11.76** (3.30; 20.22)
Insurance								
Private	0.17 (−0.52; 0.87)	−0.18 (−0.98; 0.61)	−0.17 (−0.80; 0.46)	−0.18 (−1.08; 0.71)	0.45 (−0.63; 1.53)	0.24 (−0.73; 1.21)	2.76 (−1.82; 7.35)	−3.59 (−8.77; 1.58)
Government	0.31 (−0.26; 0.89)	−0.19 (−0.85; 0.46)	0.08 (−0.44; 0.61)	−0.31 (−1.05; 0.43)	0.85 (−0.45; 1.75)	0.70 (−0.10; 1.51)	1.91 (−2.09; 5.91)	−2.90 (−7.42; 1.61)
Income, USD								
10,000–19,999	−0.06 (−0.64; 0.52)	−0.35 (−1.02; 0.34)	0.18 (−0.35; 0.71)	−0.54 (−1.30; 0.21)	0.26 (−0.65; 1.18)	0.10 (−0.72; 0.92)	1.64 (−1.94; 5.23)	−1.07 (−5.12; 2.97)
20,000–34,999	0.55 (−0.10; 1.21)	−0.32 (−1.08; 0.043)	0.35 (−0.25; 0.96)	−0.56 (−1.41; 0.29)	−0.23 (−1.27; 0.79)	0.01 (−0.91; 0.94)	−2.02 (−6.21; 2.17)	0.39 (−4.33; 5.12)
≥35,000	0.22 (−0.46; 0.90)	−0.17 (−0.95; 0.61)	0.38 (−0.23; 1.01)	−0.86 (−1.74; 0.02)	−0.32 (−1.38; 0.75)	0.02 (−0.94; 0.98)	−0.85 (−5.07; 3.36)	1.05 (−3.69; 5.81)

Reference groups: academic medical center site, female sex, not married, White race, no insurance, income <$10,000. B, unstandardized β coefficient; VA, Veterans Affairs. Statistically significant at *$P < 0.05$, **$P < 0.01$, and ***$P < 0.001$.

who experience negative emotions when delays are present also experience lower MCS QOL.

Overall, these findings offer new knowledge for understanding the relationship between delay-related behavior, self-care behaviors, and clinical outcomes for adults with type 2 diabetes in the United States. Emerging evidence has shown that delay discounting is related to glycemic control in patients with diabetes and prediabetes (16,17,26). Although we did not find any relationship between delay-related behavior and glycemic control in this sample population, this is one of the first studies to examine the relationship between both delay discounting and delay aversion and multiple diabetes self-care behaviors, A1C, and QOL. By demonstrating that higher discounting rates and higher delay aversion are significantly related to lower engagement in recommended diet and foot-care activities for diabetes management, these findings suggest that delay discounting and delay aversion may be important factors underlying long-term engagement in self-care behaviors. Similarly, these results show that both delay discounting and delay aversion are negatively associated with QOL; specifically, those who experience delay aversion tend to have lower MCS QOL. In addition, this study was conducted with a sample of adults across three racial/ethnic groups. Though racial/ethnic differences were not observed for delay discounting or delay aversion in this sample, prior research examining the role of delay discounting in diabetes has largely been in international studies conducted in primarily non-Hispanic White populations with relatively small sample sizes (16,17,26).

Although the findings presented here represent a modest relationship between delay-related behaviors and self-care activities, this relationship has clinical relevance. Specifically, understanding the central role of patient value for future health and the emotional response to delay may be an important factor to consider when establishing care plans, setting goals, and providing informational resources for patients when it comes to self-managing type 2 diabetes, namely for diet and foot care. The majority of diabetes self-management takes place at the patient level outside of the clinical encounter (31); thus, from a patient-centered care approach, understanding the role of value, response to delay, and how decision-making processes influence the performance of self-care behaviors will be critical not only to understand but to account for, across the care team, to increase self-care behaviors and improve QOL across populations (32). Moreover, because both delay discounting and delay aversion are considered modifiable factors, developing interventions to target delay discounting and delay aversion may improve engagement in self-care behaviors.

Taken together, the role of delay-related behaviors has implications for research and policy development for diabetes management. From the research standpoint, evidence for the role of delay discounting and delay aversion remains scarce, necessitating the need for additional research to examine mechanisms underlying the relationship between delay related behaviors, self-care behaviors, and diabetes outcomes. Specifically, there is a need to examine delay-related factors within intervention studies to clarify specific factors that may be necessary for promoting self-management behavior and decision-making. Delay discounting in diabetes is an emerging area for diabetes, and very few trials or interventions have been conducted examining its role, with most evidence examining the cross-sectional relationship between delay discounting and A1C (16,17). Developing behavioral interventions to target delay-related behaviors to reframe value for future health by making health-promoting decisions in the present is needed. Such interventions may be leveraged from existing high-intensity behavioral interventions using processes such as behavioral activation, which are centered around creating value for health through goal setting as well as having processes in place for coping with negative emotional responses. These types of high-intensity behavioral interventions improve diabetes outcomes (33–39), but have not been studied with delay discounting and delay aversion as modifiable targets to increase the performance of self-care behaviors. Finally, with nearly 80% of individuals with diabetes not meeting national recommendations for diabetes outcomes, policy development may be further informed by understanding the role of delay discounting and delay aversion and how to integrate the role of value and decision-making into policies surrounding the management of diabetes at a national level.

Limitations

Although this study is strengthened by the use of primary data collection across a large, diverse sample of adults with type 2 diabetes, there are some limitations that should be considered. First, this study is cross-sectional and cannot speak to any causal relationships. Future work should consider prospective assessment of delay discounting, delay aversion, and diabetes self-care and outcomes over time. Second, the variable length of A1C times from survey completion should be considered, because A1C may change substantially across 6 months. Future work should consider primary measurement of A1C at the time of survey completion. In addition, although this study included non-Hispanic White, Black, and Hispanic patients, the sample of Hispanic patients was ~3% of the study sample, so results may not be generalizable to Hispanic adults. This study was also conducted in the southeastern United States in a clinic population and so the results may not generalize across regions of the United States. Future studies should also consider the role of delay discounting and delay aversion across community populations with type 2 diabetes. Finally, this study did not include other metabolic outcomes important for diabetes care, such as blood pressure and lipids. Future studies should consider examining the association between delay discounting and other outcomes critical for diabetes management. Also, these measures of delay discounting and delay aversion were based on a self-reported scale. Future studies may consider replicating this study using laboratory-based or real-world tasks.

Conclusion

We found in a diverse sample of adults with type 2 diabetes that higher delay discounting and higher delay aversion were both significantly related with less engagement in self-care activities, and high delay aversion was specifically related to lower MCS QOL. These findings underscore the role that delay discounting and delay aversion may have in the performance of self-care behaviors and the impact on QOL. Future work is

needed to further elucidate the relationship between delay-related behaviors and diabetes management and outcomes over time. Specifically, these results highlight the importance of value and decision-making for diabetes self-management. Interventions should be considered that target delay discounting and delay aversion from a behavioral standpoint to increase value and promote healthy emotional coping for future health by supporting long-term engagement in diabetes self-care behaviors.

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