Empirical Research

A Nurse-Led Cognitive Training Intervention for Individuals With Type 2 Diabetes

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ABSTRACT

Diabetes increases the risk for cognitive impairment and doubles the rate of cognitive decline after diagnosis. In turn, cognitive dysfunction makes diabetes self-management more difficult. Nurses who help manage these conditions are focused on identifying patients at risk for complications, promoting symptom management, and preventing further decline. The purpose of the current study was to develop and pilot test a nurse-led comprehensive cognitive training intervention for individuals with type 2 diabetes mellitus (T2DM), the Memory Attention and Problem Solving Skills in Persons With Diabetes Mellitus (MAPSS-DM). The 8-week intervention combined in-person classes and online computer training. Development included: (a) adaptation of established, tested interventions; (b) interviews with stakeholders; (c) integration of course content; and (d) pilot testing of the intervention in a one-group, pre-/posttest design ($N = 19$). Postintervention scores improved in all areas; improvements were statistically significant for diet adherence ($t[18] = -2.41$, $p < 0.005$), memory ability ($t[18] = 5.54$, $p < 0.01$), and executive function ($t[18] = 3.11$, $p < 0.01$). Fifty-eight percent of participants stated the intervention helped their diabetes self-management, and 74% indicated they wanted to continue using cognitive strategies learned in the intervention. Results from this study showed the MAPSS-DM to be a promising cognitive training intervention for individuals with T2DM.

Targets: Individuals with T2DM.

Intervention Description: In-person classes and online computer training of a cognitive training intervention.

Mechanisms of Action: Participants who completed the intervention would show improved cognitive function, which would result in improved self-management adherence followed by better glycemic control.

Outcomes: Improved diabetes self-management and sustained use of learned cognitive strategies.

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Individuals with type 2 diabetes mellitus (T2DM) are at higher risk for developing cognitive dysfunction than the general population, and approximately 50% of older adults with T2DM will have some form of cognitive impairment (Munshi, 2017). The underlying mechanism of cognitive changes in T2DM is unclear, but hyperglycemia and hypoglycemia, oxidative stress, and insulin resistance are all believed to contribute to detrimental changes. In addition, prior research has revealed that individuals with T2DM are not routinely told that cognitive dysfunction is considered a complication of T2DM (Cuevas, Stuifbergen, Brown, & Rock, 2017). This is unfortunate because T2DM has a large self-management component that relies on understanding complex information regarding diet, exercise, medications, and glucose monitoring. If cognitive function is impaired, these tasks may be more difficult, and interventions to improve glucose control may be less effective. Despite this potential problem, few studies have investigated how self-management relates to cognitive function, and even fewer studies have examined interventions designed to improve cognitive function in T2DM. Studies that have investigated these variables have been limited and included measurement of nondiabetes-specific activities of daily living or focused on only one aspect of T2DM self-management (e.g., diet) or one cognitive domain (e.g., memory) (Camp, Fox, Skrajner, Antenucci, & Haberman, 2015; Whitelock et al., 2015).

The primary objective of the current study was to develop a cognitive function intervention and to implement the intervention in a multiethnic sample of individuals diagnosed with T2DM. The specific aims were to:

1. Refine a current cognitive training intervention and tailor it for individuals with T2DM by using the existing literature and qualitative data from participants with T2DM.
2. Conduct a pilot study of the adapted intervention for participants with T2DM.

COGNITIVE TRAINING APPROACHES

The current study built on prior work examining the relationships of perceived memory, cognitive ability, T2DM self-management, and glycemic control (Cuevas & Stuifbergen, 2017). The goal of this intervention was to foster self-efficacy for compensatory cognitive skills with in-person classes and individual home-based, computer-assisted practice exercises related to those cognitive domains. In the case of cognitive impairment, only a few single treatments have more than an unsustained symptomatic effect (Rebok et al., 2014). Treatments for other chronic illnesses such as cancer or cardiovascular disease have been improved though the use of combination therapies (Park, Jung, Kim, & Bae, 2017; Pressler et al., 2015; Towe, Patel, & Meade, 2017). Thus, therapies to optimize cognition in individuals with T2DM should address as many components as possible.

Cognitive training uses theoretically driven strategies and skills as well as "guided practice" on various cognitive tasks (Mowszowski, Batchelor, & Naismith, 2010). Cognitive training includes teaching techniques and strategies to augment strengths and adapt to weaknesses as well as computerized games and cognitive strategies targeting different cognitive domains (Mowszowski et al., 2010). Using a combination of in-person class sessions focusing on lifestyle management for cognitive health and online programs for cognitive training may have a positive synergistic effect on cognitive function by optimizing diet, reducing stress, increasing physical activity, and stimulating the brain, which are all components of T2DM self-management and cognitive health (Sigmundsdottir, Longley, & Tate, 2016).

Providing cognitive training that incorporates widely available and increasingly acceptable technology is an innovative way to improve T2DM self-management. Nurse-led diabetes self-management education has been shown to help patients lower glycated hemoglobin (A1C) and increase self-efficacy; however, no other studies were identified that used comprehensive lifestyle-based cognitive training as an intervention in T2DM (Azami, 2018; Cuevas, 2019; Tshiananga et al., 2012). The current study sought to fill this gap by adding the component of cognition to the study of T2DM self-management—a novel and important focus. The inclusion of the online format with traditional group training has the potential to increase engagement and encourage individuals with T2DM to make crucial changes in self-management behavior.

Current standard cognitive training is delivered in person in a clinic or laboratory by a trained researcher or educator (Becker, Henneghan, Volker, & Mikan, 2017). The combination of group and individual online training has the advantage of enabling self-paced work with quick feedback as well as improving convenience, replicability, and accessibility. Other key benefits are:

- Consistency in intervention administration.
- Ability to generate multiple forms of testing with progressively challenging activities.
- Decreased cost of administration.
- Increased access for a broader population.

Although online cognitive training is in the beginning stages of research, it has been effective for improving core

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cognitive abilities in memory, reasoning, and executive function (Ferguson et al., 2007; Stuifbergen et al., 2012). For example, Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE), which used an earlier version of the online exercises (BrainHQ) that were used in the current study, showed such training increased engagement and improved long-term retention in older adults (Rebok et al., 2014). The ACTIVE randomized clinical trial (RCT) also was one of the first trials to report significant transfer effects at 5 and 10 years postintervention. At 10 years postintervention, participants in the intervention groups had less decline in instrumental activities of daily living than in the control group (Rebok et al., 2014).

A systematic review of seven cognitive training RCTs demonstrated that after 2 years of follow up, persistent protective effects and transfer of those effects were reported (Valenzuela & Sachdev, 2009). Improvement in Memory With Plasticity-based Adaptive Cognitive Training, the largest RCT to examine whether a cognitive training program, BrainHQ, can improve cognitive abilities in adults, demonstrated improvements in memory and processing speed, as well as an increase in self-reported positive changes in everyday lives (Smith et al., 2009). In 2013, the Iowa Healthy and Active Minds Study reported participants using the BrainHQ cognitive training program had greater improvement in cognitive capabilities than participants who were trained on other games (Wolinsky, Vander Weg, Howren, Jones, & Dotson, 2013).

The Metabolic Enhancement for Neurogenerative Disorders study used a comprehensive program that involved diet, exercise, and online cognitive training (Bredesen, 2014). The study reported that participants with mild cognitive impairment showed the most impact and suggested that the program may be successful in delaying progression to dementia. In addition, cognitive training can give individuals a greater sense of control over cognitive changes and have a beneficial effect on quality of life (Buckley, Saling, Frommann, Wolfsgruber, & Wagner, 2015). This research is not complete; large studies have yet to be conducted to determine how improvement on neuropsychological tests as the result of cognitive training influences T2DM self-management.

METHOD

Study Design

Approval for the study was obtained from the University of Texas at Austin Institutional Review Board. This pilot study used a sequential exploratory mixed-method design with two phases. First, the current Memory Attention and Problem Solving Skills in Persons With Multiple Sclerosis (MAPSS-MS) cognitive training intervention was modified (content and format) based on input from interviews with 10 individuals diagnosed with T2DM (Memory Attention and Problem Solving Skills in Persons With Diabetes Mellitus [MAPSS-DM]). Second, the feasibility of using this adapted intervention was determined using a one-group, pretest/posttest design with 19 participants. The first phase took place during a 3-month period, and the second phase took place during a 6-month period. The convenience sample of participants for both phases was recruited by distributing flyers at a multisite endocrinology clinic located in central Texas. The flyer listed key points about involvement in the study as well as directions on how to contact the principal investigator. Trained research staff at the clinic also identified potential participants and assisted in the screening process.

Inclusion criteria were participants aged 40 to 70 years who had been diagnosed with T2DM for at least 2 years. Having T2DM for ≥2 years provided participants with the experience of living with T2DM and self-management requirements. The age range was set at 40 to 70 years because the prevalence of T2DM is higher for adults in middle to late-middle age and the likelihood of differences in intervention preferences and responses between older and younger adults with diabetes. In addition, those with type 1 diabetes typically present at a younger age and may require different treatments and self-management strategies.

Participants also had to have subjective concerns about their cognitive function, which was assessed using the Perceived Deficits Questionnaire (PDQ). A score ≥10 on the PDQ was required for participation. Other inclusion criteria were that participants speak and read English and have access to transportation as well as telephone and internet services. Exclusion criteria were vision that could not be corrected to 20/70, other medical causes of dementia or disorders that may affect cognition (e.g., depression), and other limitations that precluded study activities (e.g., stroke, physical disability, geographic distance from the study site).

In Phase 1 of the project, semi-structured interviews were conducted with 10 individuals with T2DM and perceived cognitive problems (Cuevas et al., 2017). In Phase 2 of the intervention, an additional 19 participants completed pre- and posttest measures of diabetes self-management adherence and perceived cognitive function. At posttest, participants also completed a survey about intervention logistics, satisfaction and usefulness of the intervention, and perceived changes in diabetes self-management.

Development of the MAPSS-DM Intervention

The adaptation of the MAPSS-DM intervention was based on the MAPSS-MS intervention developed by one of the principal investigators (A.K.S.) of the project (Stuifbergen et al., 2012). It is based on Bandura's (2001) theory of self-efficacy with the goal to build self-efficacy for completing cognitive strategies to improve day-to-day function. The MAPSS-DM altered the goal slightly to include aspects of T2DM self-management as a background for which to practice cognitive strategies. The approach of this intervention included content presentation in a variety of methods (i.e., online and in-person), as well as goal-setting and interactive approaches to engage participants. In addition, semi-structured interviews with 10 adults with T2DM were conducted to obtain their opinion on the proposed intervention content, class logistics, and experiences with cognitive problems. The interviews contained questions such as, "What, if any, problems have you noticed with your cognitive function since your diagnosis with diabetes?" and "How do these class topics relate to your life?" The full results of these interviews are published elsewhere (Cuevas et al., 2017).

All content was developed at an 8th-grade reading level. Principles of adult learning were used along with weekly goal setting by participants. **Table 1** describes the content of each session. Phase 2, the final intervention, consisted of four 2-hour classes that met every other week and were led by an RN. Participants also were asked to complete three 45-minute sessions of the online computer training each week. Each educational session built on the didactic information and included activities to improve cognitive health by practicing strategies in class and on the computer. The computer training program, BrainHQ, was developed by Posit Science (2017) and was the same computer program used in the original MAPSS-MS intervention. In prior work using the MAPSS-MS intervention, participants tested three different online training programs. Participants had specific complaints about two of the online programs; participants indicated they found the programs to be "frustrating," they disliked the use of loud noises, and the opportunities for feedback were limited. The Posit Science program was rated the highest.

Tracks in the computer component of the intervention include attention, memory, executive function, and processing speed. These are organized so that the most basic skills are addressed first (i.e., attention). As participants move through the activities, tasks become more difficult and challenging. BrainHQ meets the Institute of Medicine's five requirements for a brain-training program (Blazer, Yaffe, & Liverman, 2015):

1. Transfer of training to other lab tasks that measure the same cognitive construct as does the training task.
2. Transfer of training relevant to real-world tasks.
3. Evaluation using an active control group whose members have the same expectations of cognitive benefits as do members of the experimental group.
4. Retention of trained skills.
5. Benefits of the training product replicated by research groups other than those selling the product.

The version used for this project was subscription-based. One of the principal investigators (A.K.S.) subscribed to the website service for a fee for each participant ($70) so they had unlimited access to log in and complete the exercises from any computer with internet access. The fee also allowed the research team to monitor and analyze engagement and progress with the games. At the end of the project, participants were made aware that there was a free version of the program, without principal investigator oversight, if they wanted to continue to practice.

Data Collection

Study variables and measures are described in **Table 2**. Members of the research team had used these measures effectively in previous studies. Data were gathered pre- and postintervention by a research assistant at data collection visits scheduled for each participant. Demographic information, A1C, and body mass index (BMI) were collected for the sample.

Participants completed the Summary of Diabetes Self-Care Activities Questionnaire as a measure of adherence to T2DM self-management activities to examine the potential effect of the intervention on those activities (Toobert, Hampson, & Glasgow, 2000). The General Self-Efficacy Scale was used as a measure of confidence in the ability to change outcomes in a variety of situations (Schwarzer & Jerusalem, 1995). The Multifactorial Memory Questionnaire (MMQ) and the Barkley Deficits in Executive Function Scale–Short Form (BDEFS-SF) were used to describe two types of perceived cognitive function most affected in diabetes (Barkley, 2014). Higher scores on the BDEFS-SF indicated lower levels of perceived executive function. Because depression and symptoms related to depression are associated with diabetes as well as with working memory, the 10-item Center for Epidemiologic Studies Depression Scale was used as a measure of depressive symptoms (Stahl et al., 2003). Additional data were collected at the end of the study us-

TABLE 1

Class Content for Type 2 Diabetes Mellitus (T2DM)

Week	Content
1	Understanding T2DM, symptoms, complications, and medications
	Understanding how cognitive function is related to T2DM
	Attending orientation to computer training
	Discussing effective strategies to facilitate better communication with health care providers (e.g., understanding instructions or recommendations from health care providers)
	Learning strategies to enhance attention and problem solving
3	Learning strategies to enhance memory
	Addressing resources and barriers to self-management (e.g., planning ahead for meals, organizing medications) that take into account elements of executive functioning
	Learning visuospatial skills required for blood glucose self-monitoring
5	Addressing ADA dietary recommendations and how they can benefit cognitive health
	Discussing favorite recipes, healthy food preparation, eating out, and portion control
	Acknowledging and appreciating stress associated with diabetes and cognitive issues
	Providing resources for mental health care services
	Learning strategies to manage stress
8	Addressing ADA activity recommendations and benefits of following the guidelines on cognitive function
	Discussing practical ways to increase activity
	Reviewing cognitive skills/training and the potential impact on self-management skills including blood glucose monitoring, medication adherence, diet, and exercise
	Addressing resources and barriers to maintaining cognitive function

Note. ADA = American Diabetes Association.

ing a six-item rating scale with responses ranging from 0 (*strongly disagree*) to 3 (*strongly agree*) on items such as, "The activities kept my interest" and "The computer activities helped improve my cognitive skills."

Data Analysis

Results were entered into a computer database for analysis using IBM SPSS Statistics version 23. Data were checked for accuracy and evaluated for violations of statistical tests. Reliability estimates (internal consistency) were determined for each instrument, and an alpha >0.70 was considered acceptable. Descriptive analyses were performed to obtain a description of the sample on demographic and illness-related variables. Paired *t* tests were used to examine pretest and posttest differences. The level of significance was set at 0.05. Correlations also were run to examine the relationships between variables. For example, the associations between A1C and memory, A1C and executive function, and T2DM self-care and memory were analyzed.

RESULTS

Sample Description

During the screening period, 112 patients with cognitive complaints were recruited (**Figure 1**). Of these, 32 patients did not meet the PDQ criteria and 19 patients had a history of dementia. After initial screening, 42 patients declined to participate. Of the remaining patients, 19 consented to participate.

Mean age of participants was 55 years (*SD* = 10.9), mean length of time with T2DM was 7 years (*SD* = 4.8), and mean A1C was 8.3% (*SD* = 1.8). The sample was 32% non-Hispanic White, 53% Hispanic, and 16% African American (**Table 3**).

Seventy percent of participants attended at least three of the four sessions. Average time spent per week on the program was 106 minutes (range = 9 to 120 minutes; *SD* = 35.4 minutes), which was less than the requested time of 45 minutes, 3 days per week, for a total of 135 minutes per week.

Baseline adherence to T2DM self-management activities was low (**Table 3**). Participants completed an average

TABLE 2

Study Measures

Measure	Description of Measure
Physiological measures (preintervention only)	
Glycated hemoglobin (A1C; laboratory: blood samples)	National standard measure of glycemic control for a 3-month period
Body mass index (weight, height)	
Self-report measures (pre- and postintervention)	
Demographics (background information)	Age, gender, years with diabetes, ethnicity/race
Diabetes self-care (Summary of Diabetes Self-Care Activities Questionnaire)	18 items; participants answered questions regarding how many days in the past 1 week they performed a certain aspect of diabetes self-management behaviors, such as diet, smoking, and physical activity; inter-item correlations ranged from $r = 0.20$ to 0.76 for four subscales; 4-month test–retest reliability ranged from $r = -0.05$ to 0.78.
Self-efficacy (General Self-Efficacy Scale)	10 items; participants rated confidence in their ability to influence outcomes using a 4-point scale (1 = *not true at all*, 2 = *hardly true*, 3 = *moderately true*, 4 = *exactly true*) for items such as "I can always manage to solve difficult problems if I try hard enough"; Cronbach's alpha ranged from 0.76 to 0.90.
Memory (Multifactorial Memory Questionnaire)	57 items; questionnaire assesses contentment with memory, subjective memory capability, and use of memory aids; for the Contentment subscale, participants rated their level of agreement using a 5-point scale (1 = *strongly agree*, 2 = *agree*, 3 = *undecided*, 4 = *disagree*, 5 = *strongly disagree*); for the Ability subscale, participants indicated the frequency with which each memory failure occurred in the past 2 weeks using a 5-point scale (1 = *all the time*, 2 = *often*, 3 = *sometimes*, 4 = *rarely*, 5 = *never*); for the Strategy subscale, participants rated the frequency of use of certain memory strategies using a 5-point scale (1 = *never*, 2 = *rarely*, 3 = *sometimes*, 4 = *often*, 5 = *all the time*); Cronbach's alpha was 0.95 for Contentment, 0.93 for Ability, and 0.83 for Strategy.
Executive function (Barkley Deficits in Executive Functioning Scale—Short Form)	20 items; participants assessed the frequency at which they exhibited certain behaviors in specific executive functioning areas within the past 6 months using a 4-point scale (1 = *never or rarely* to 4 = *very often*); areas include self-management of time, self-organization/problem-solving, self-restraint, self-motivation, and self-regulation of emotion; Cronbach's alpha for internal consistency of the short-form scale was 0.92.
Feasibility measures	
Accessibility of intervention (recruitment and retention)	Logs of recruitment activities
Practice of skills (homework logs)	Measured time spent practicing cognitive training skills
Satisfaction with intervention (project team developed)	(a) Six-item rating scale with responses ranging from 0 (*strongly disagree*) to 3 (*strongly agree*) on items such as "The activities kept my interest," and "The computer activities helped improve my cognitive skills" to be assessed at the end of the intervention; (b) focus groups were asked 12 open-ended questions regarding cognitive strategies tried as well as feedback on class sessions and online games (e.g., "What cognitive strategies did you try during the 8 weeks?" and "What could be changed about the classes to make them better?").

of 2.1 days per week of physical activity and only 1.5 days of specific exercise. Rates of "healthful eating" averaged 2.7 days, and consumption of high-fat foods averaged 4.6 days. Length of time with T2DM was significantly correlated positively with some of the self-management activities: healthful eating in the past month (r = 0.59, p < 0.01), healthful eating in the past week (r = 0.61, p < 0.01), eating five or more servings of fruits and vegetables per day (r = 0.547, p < 0.5), participating in 30 minutes of physical activity in the past week (r = 0.70, p < 0.01), and participating in a specific exercise in the past week (r = 0.63, p < 0.01). General self-efficacy was significantly and positively correlated with diet (r = 0.50, p < 0.05), exercise (r = 0.61, p < 0.01), and foot care (r = 0.51, p < 0.5), and negatively correlated with perceived problems with executive function (r = –0.67, p < 0.1).

Baseline scores on the BDEFS-SF, but not the MMQ, were significantly correlated with self-management activities (general diet, r = –0.67, p < 0.01; exercise, r = –0.73, p < 0.01; foot care, r = –0.52, p < 0.05) and positively correlated with eating high-fat foods in the past week (r = 0.69, p < 0.01). Rates of self-management adherence with lower perceived executive function were lower for exercise only. A1C was not significantly correlated with the cognitive variables.

Postintervention scores in all areas improved, but statistically significant improvements were seen for only diet (t[18] = –2.41, p < 0.05), perceived memory ability (t[18] = 5.54, p < 0.01), and perceived executive function (t[18] = 3.11, p < 0.01).

Fifty-eight percent of participants believed the intervention helped their T2DM self-management, and 74% said they wanted to continue using the cognitive strategies learned in the intervention. However, 32% agreed strongly with the statement, "The amount of time burden for the intervention was high." In addition, the cognitive strategies were rated as more helpful than the computer training (53% vs. 47%).

DISCUSSION

Despite the strong association between T2DM and cognitive dysfunction, little has been done to treat both conditions concurrently. One potential solution to this problem is to merge and adapt established, tested interventions to meet the needs of both conditions. Despite a small sample size, the results of the current study suggest that a comprehensive cognitive training intervention using online and in-person training can be successfully adapted for adults with T2DM and helpful in improving facets of

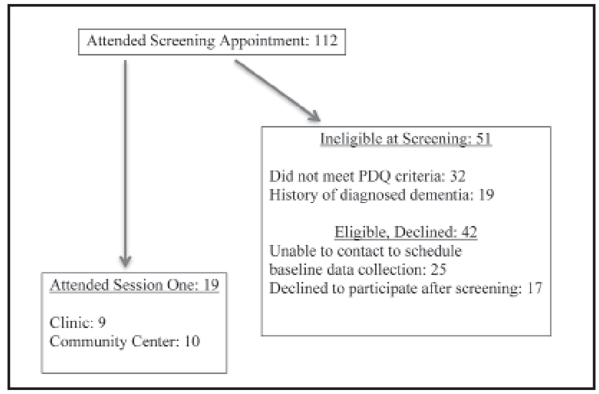

Figure 1. Recruitment flow chart.
Note. PDQ = Perceived Deficits Questionnaire.

self-management. Strengths of the study were the focus on increasing self-efficacy for using compensatory strategies and lifestyle changes that benefited both T2DM and perceived cognitive dysfunction, as well as a focus on self-management. Although only perceived memory ability and executive function improved after the intervention, positive changes were seen in participants' reports of cognitive problems and self-management. They reported using more strategies, which may be important in showing what can be done in daily life to improve cognitive abilities. The correlational relationships need to be interpreted with caution because of the small sample size, but the results indicated these relationships merit further investigation.

Another strength was the use of a nurse diabetes educator. Nurses who help manage chronic conditions such as diabetes are ideally positioned to provide expertise, monitoring, and feedback to help provide individualized care (Burke, Sherr, & Lipman, 2014). Nurses who are diabetes educators use theory to address the complexities of behavior change and have been successful in promoting behavior change, decreasing diabetes-related stress, and increasing empowerment (Duncan et al., 2011; Siminerio, Ruppert, & Gabbay, 2013). Although this study focused on increasing self-efficacy for use of cognitive strategies, it was centered in aspects of diabetes self-management, and the RN educator was skilled in helping participants become effective self-managers.

The close-ended intervention satisfaction questions also lend support for the potential efficacy of the intervention. Most participants noted that although a time burden was present, they thought it was manageable. In addition, all participants reported an increase in knowledge at the end of the intervention, and they had new ideas for self-management skills to maintain glycemic control and cognitive health. The comments also demonstrated the overall

TABLE 3

Participant Characteristics (*N* = 19)

Characteristic	*n* (%)	Range	Mean (*SD*)	
Age (years)	19	40 to 70	55.1 (10.9)	
A1C (%)	19	5.4 to 12	8.3 (1.8)	
Length of time with T2DM (years)	19	2 to 21	7.1 (4.8)	
Race				
Hispanic	10 (52.6)			
Non-Hispanic White	6 (31.6)			
African American	3 (15.8)			
Female	11 (57.9)			
SDSCA Variables			**Pretest**	**Posttest**
General diet		0 to 7	2.9 (1.9)	4.4 (2.1)
Specific diet		0 to 6	3.8 (1.6)	4.2 (1.5)
General exercise		0 to 6	1.8 (1.4)	2.9 (1.5)
General glucose testing		0 to 7	2.3 (1.2)	3.4 (2.5)
General foot care		0 to 7	2.6 (2.5)	3.6 (2.8)
Days of smoking in the past 1 week		0 to 3	0.3 (0.8)	0.2 (0.7)
Cognitive Variables				
Memory				
Contentment		28 to 54	40.0 (5.8)	23.5 (6.3)
Ability		31 to 86	45.5 (11.4)	24.8 (7.3)
Strategies		12 to 101	32.8 (19.6)	40.0 (3.5)
Executive function				
Time		4 to 14	10.0 (2.6)	9.0 (2.7)
Self-organization		4 to 12	8.5 (2.4)	6.9 (1.4)
Restraint		4 to 14	7.9 (2.9)	5.6 (1.7)
Motivation		4 to 11	6.9 (2.8)	5.8 (1.7)
Self-regulation		4 to 14	8.2 (2.5)	5.3 (1.4)
Total		24 to 57	41.6 (9.9)	32.8 (5.1)
CES-D–total		10 to 18	14.6 (2.1)	12.3 (1.1)
GSES–total		20 to 40	28.2 (3.2)	32.2 (4.8)

Note. A1C = glycated hemoglobin; T2DM = type 2 diabetes mellitus; SDSCA = Summary of Diabetes Self-Care Activities Questionnaire; CES-D = Center for Epidemiologic Studies Depression Scale; GSES = General Self-Efficacy Scale.

design and format of the intervention was helpful in reinforcing the content. However, although attendance at the class sessions was better than participation in the online games, most participants recommended moving the intervention to a completely online format (i.e., webinar instead of in-person classes) to reduce the time and travel burden. Ninety percent thought that the session length was appropriate and that four sessions was the correct number of sessions. However, recruitment and retention could be improved if the time burden associated with use of the online program could be addressed by adjusting the recommended time to 20 minutes, 7 days per week (for a total of 135 minutes) as suggested by participants.

Other comments from participants offered insights as to why they thought the intervention was beneficial. Relating the cognitive strategies to diabetes self-management was believed to be helpful in applying the strategies to everyday life. Offering portions of the training at home and online was perceived as convenient and eased completion of many of the assignments. Participants were almost unanimous in saying they would refer others to this type of training because it focused on both T2DM and cognitive function, which was an area they were concerned about but had little information on the underlying pathophysiology or how to prevent or treat it. The most frequent negative comment (and reason for missing a class session) was related to the travel time needed to attend the in-person meetings.

LIMITATIONS

Interpretation of the findings from this project is limited by the small sample size and lack of a comparison group. The inclusion of a sample with more than 50% of participants belonging to underrepresented minority populations is a strength. In addition, participants may have been more motivated for behavioral change as they volunteered for a time-consuming intervention and expressed concern with cognitive problems during the screening process of the study. This group also had good access to health care and the internet, and participants also had relatively well-controlled glucose levels. Therefore, this sample was somewhat biased toward a higher educated, better-controlled group of individuals with T2DM. Conversely, this might be considered a strength as these individuals could be considered "experts" in T2DM self-management and could represent some of the best sources of information to inform the design of future interventions. In addition, the study relied on self-reported data, which might include answers influenced by social desirability. In future studies, researchers might want to add neuropsychological tests in which participants are observed as they perform activities for comparison.

Expectations of change in cognitive function also may have influenced results. In other words, those who participate in cognitive training believe it will lead to improvement and lead toward more effort in post-tests. Boot et al. (2013) controlled for these expectations in two survey studies with 400 healthy adults and found that those effects could be explained apart from the true treatment effects. The results of this type of study emphasize the need for future projects to test for those differential expectations.

Another limitation is the multicomponent nature of the intervention design. Due to the small sample size, the ability to determine whether one or both of the components is responsible for the outcomes and the power to find statistically significant effects is limited. The research team currently is proposing a larger RCT to address these issues.

CONCLUSION

The MAPSS-DM is a promising intervention. In a time when rates of comorbid T2DM and cognitive dysfunction are rising, it is important to explore how interventions can become more sensitive to both conditions. The MAPSS-DM provides the first evaluation of a comprehensive cognitive training intervention for individuals with T2DM. Thus, despite difficulties with recruitment, further testing of comprehensive cognitive training interventions for individuals with T2DM is recommended. A collaborative, multidisciplinary intervention can help provide a guide for feasible studies that contribute to more tailored approaches to the management of T2DM and cognitive problems. In addition, documentation of study processes will allow others to replicate the study and understand the contextual differences important to future dissemination. In the future, efficacy testing will build knowledge specific to promoting the cognitive health of individuals with T2DM.

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