Computerized cognitive training for older adults at higher dementia risk due to diabetes: findings from a randomized controlled trial

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Short title: Cognitive training for older diabetic adults

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Abstract

Background: To evaluate the effects of adaptive and tailored computerized cognitive training [CCT] on cognition and disease self-management in older adults with diabetes.

Methods: Single-blind trial. Eighty-four community-dwelling older adults with diabetes were randomized into a tailored and adaptive computerized cognitive training [TA-CCT] or a generic, non-tailored or adaptive CCT condition [GCCT]. Both groups trained for 8-weeks on the commercially-available CogniFit program and were supported by a range of behavior change techniques [BCTs]. Participants in each condition were further randomized into a global or cognition-specific self-efficacy [SE] intervention, or to a no-SE condition. The primary outcome was global cognition immediately following the intervention. Secondary outcomes included diabetes self-management, meta-memory, mood, and self-efficacy. Assessments were conducted at baseline, immediately after the training, and at a 6-month follow-up. **Results:** Adherence and retention were lower in the GCCT condition, but the self-efficacy intervention was not associated with adherence. Moderate improvements in performance on a global cognitive composite at the post-treatment assessments were observed in both cognitive training conditions, with further small improvement observed at the 6-month follow-up. Results for diabetes self-management showed a modest improvement on self-rated diabetes care for both intervention conditions following the treatment, which was maintained at the 6-month follow-up. **Conclusions:** Our findings suggest that older adults at higher dementia risk due to diabetes can show improvements in both cognition and disease self-management following home-based multi-domain computerized cognitive training. These findings also suggest that adaptive difficulty and individual task tailoring may not be critical components of such interventions.

Trial registration: www.ClinicalTrials.Gov - NCT02709629, registered on: 25/2/16

Keywords: self-management, self-efficacy, mild cognitive impairment, cognition

Background

Prevention of dementia is a global health priority, and according to an increasingly dominant view, the elimination, reduced exposure to, and better management of several common modifiable risk factors can lead to the prevention of more than a third of all dementia cases [1]. A relationship between chronic metabolic conditions and cognitive ageing is firmly established with population studies repeatedly demonstrating a link between type-2 diabetes and increased risk of cognitive decline [2,3], conversion of mild cognitive impairment to dementia [4], and development of dementia-spectrum disorders in general [5-7]. Diabetes-related biological processes have been implicated in the genesis and maintenance of the pathophysiological mechanisms that give rise to neurodegenerative diseases, including Alzheimer's disease and vascular dementia VAD; [8,9-11].

In people with diabetes, effective disease self-management - a daily regimen encompassing such behaviors as adherence to medication intake, to appropriate dietary and exercise guidelines, blood glucose monitoring, foot care and regular health-care visits – is of vital importance in the prevention of diabetes-related complications, including cognitive and functional decline [12,13]. However, subtle cognitive dysfunction in older adults with diabetes is common and associated with worse diabetes self-management [12,14]. Therefore, the maintenance of cognitive abilities in older adults with diabetes by means of effective cognition-oriented treatments may play an important role in the prevention of diabetes-related complications and the associated downward spiral. Importantly, evidence supports the hypothesis that psychosocial behaviors may play an important role in attenuating the association between cognition and pathophysiological changes in older age [15]. Cognitive training (CT), the guided practice on tasks targeting specific cognitive abilities and processes, is associated with improved performance on untrained cognitive measures in cognitively healthy older adults[16] , as well as in people at risk of dementia due to mild cognitive impairment [17], but by the time mild to moderate dementia is diagnosed, CT appears to be of

little benefit [18]. It has therefore been suggested that CT may be offered to older adults at risk of dementia due to mild cognitive impairment in the efforts to prevent or delay the onset of dementia [19]. An active debate remains, however, on the extent and limits of transfer of gains from CT to more distal outcomes [20-22], and whether certain CT elements (e.g., adaptive task difficulty, personal tailoring) are related to gains is not clear. In the first report concerning cognitive training for persons with diabetes, Whitelock and colleagues have recently found that adults with type 2 diabetes improved on a measure of visuospatial attention following working memory training [23]. However, to date there has been no investigation of the potential of multidomain CT to improve global cognition or diabetes self-management outcomes in older adults at higher dementia risk due to diabetes. Further, self-efficacy (SE), a person's belief that they can achieve a goal, has been associated with diabetes self-management [24], but whether or not augmenting CT with techniques to boost SE leads to improved treatment adherence or outcomes has not been investigated. We therefore conducted a randomized controlled trial with the primary aims of comparing the effects of tailored and adaptive multidomain cognitive training with a simplified, non-adaptive and 'generic' cognitive training in relation to 1) global cognition (primary outcome) and 2) diabetes self-management (secondary outcome), in older adults with diabetes; Secondary aims included the effects of the intervention on performance in specific cognitive domains, self-reported mood and memory ability, activities of daily living, and the impact of a secondary self-efficacy intervention on training adherence or outcomes. The detailed rationale, along with the complete methods have been published separately [25] and therefore only key design features are summarised below.

Methods

The trial was conducted in the metropolitan Tel-Aviv area, with recruitment commencing in October 2015, and follow-up completed by September 2017. The trial was approved by the

Ethical Review Boards at Sheba Medical Center (SMC-0573-13) and at Maccabi Health Services (MHS 25/2014) and was retrospectively registered in ClinicalTrials.gov (NCT02709629). Differences between the current paper and the published protocol [25] are listed in the *Supplementary Material*.

Participants

Eighty-five community dwelling older adults (*M* age 71.45, *SD* = 4.85; 51 male) enrolled in the study. They were recruited through media advertising, diabetes education groups, fliers distributed in local health centers, and through a large observational study (The Israel Diabetes and Cognitive Decline study [26]). Participants were required to have a diagnosis of Type 2 Diabetes but no diagnosis of dementia or Alzheimer's disease. See the trial protocol [25] for sample size calculations, a complete list of eligibility criteria, and screening procedure. All participants provided written informed consent, and all procedures were approved by the Institutional Review Boards of Sheba Medical Centre and of Maccabi Health Services.

Interventions

Following baseline assessment, randomization software was used to assign participants to a tailored and adaptive computerized cognitive training (TA-CCT) or a generic computerized cognitive training condition (G-CCT) at a 1:1 ratio by an independent researcher who concealed the results of the randomization from the investigators. Within the cognitive training conditions, participants were further randomized into a global self-efficacy, cognitive training self-efficacy, or a no self-efficacy condition. Participants and those completing outcome assessments were blind to condition allocation. Participants in both training conditions trained at their home on a commercially-available multi-domain computerized cognitive training platform [Cognifit™]. All participants also received psychoeducation and a range of behavior-change techniques (BCTs) were used to optimize adherence and perseverance to the CCT intervention. These behavioral components were developed using a taxonomy of BCTs and the associated Theoretical Domains Framework outlined by Michie

and colleagues as a guide [27]. Details of all BCTs can be found in the protocol [25].

Computerized cognitive training conditions

The TA-CCT condition differed from the G-CCT condition in three key features: 1) Individual tailoring. Participants in the TA-CCT condition were assigned specific tasks based on their cognitive profile of strengths and weaknesses, established at baseline through a computerised assessment built-in to the training platform, and continuously updated over the training period. In contrast, task allocation in the G-CCT condition was similar for all participants, irrespective of their cognitive profiles. 2) Adaptive difficulty level. In the TA-CCT condition, task difficulty changed in response to actual performance levels to adjust and maintain levels of challenge, whereas in the G-CCT condition task difficulty across sessions remained fixed. 3) Session-based feedback. Participants in the TA-CCT condition viewed their performance feedback at the end of each session, whereas participants in the G-CCT condition could only see their baseline and end-of-training scores.

Participants were instructed to train 3 times per week over an 8-week period, and to complete 2 training sessions on each training day, with a session lasting 10-15 minutes (total of 48 sessions). Each session included a unique combination of 3 types of tasks reflecting a range of cognitive abilities. Three months following the completion of the main training phase, participants who adhered to at least 50% of the prescribed training and who did not formally withdraw from the study, were invited to complete a booster training, which included three additional training sessions over a 1-week period.

Self-efficacy (SE) interventions

Using a BCT taxonomy and the Theoretical Domains Framework [28,29], three techniques were included in the SE interventions, namely, “focus on past success”, “vicarious experience”, and “verbal persuasion”. These techniques were delivered as a combination of communications with study participants as part of the routine fortnightly support phone calls

and augmented by two short video clips sent to participants via email. During the phone calls, participants in both SE conditions were specifically asked to reflect on their past success and were guided to focus on either a general or a cognitive-specific past experience, depending on their SE condition allocation. Scripted verbal persuasion around capacity to complete the intervention trial was also included in these phone conversations. In the two videos sent to participants, an actor discussed a general past success (global SE condition) or their success in a CCT intervention (cognitive SE condition). Participants assigned to the 'no SE condition' received a standard phone monitoring call every two weeks, but these calls did not include the delivery of SE-specific BCTs, and no videos were sent to these participants.

Assessments, Outcomes and Measures

Participants were assessed at baseline, upon completion of the treatment period (post-intervention) and at 6-month follow-up by trained psychologists blind to group allocation. The primary outcome was general cognitive ability, as reflected in a standardized composite score derived from the entire cognitive assessment battery, which consisted of several common cognitive measures, namely: Mini-Addenbrooke's Cognitive Evaluation (M-ACE), L'Hermitte Board, Logical Memory test, Rey Auditory Verbal Learning Test (RAVLT), Rey-Ostrich Figure Copy Test (ROFCT), Verbal Fluency, Digit Span, Digit-Symbol Coding, Boston Naming Test and Trail-Making Task. The main secondary outcome was diabetes self-management, based on the self-reported and informant-reported Diabetes Self-Management Questionnaire (DSMQ). Other secondary outcomes included cognitive performance in memory and non-memory domains, general and cognitive-training related self-efficacy, meta-memory (subjective perception of memory functioning), mood symptoms, and caregiver burden and distress (informant-reported). Complete details of the outcomes, measures and their references and methods used to derive composite scores can be found in the trial protocol [25].

Statistical Analysis

Data were analysed with SPSS v22 following a pre-specified plan [25]. All statistical procedures are also described in detail in the *Supplementary Material.* The Global Cognition composite score was computed as the mean of the z-scores on all cognitive measures. Composite scores were also calculated for the 'Learning and memory', 'Delayed memory' and 'Non-memory' domains. Using an intention to treat approach, Linear Mixed Models were fitted to evaluate outcomes, comparing three main models. The first model included the fixed main effects of training condition, self-efficacy condition, and assessment timepoint; and a random intercept by participant. In the second model all two-way interactions between these variables were added as fixed effects, and the main effects remained in the model. The third model contained the same as the second, as well as a three-way interaction between training condition, self-efficacy condition, and assessment timepoint. Parameters were estimated using Restricted Maximum Likelihood, with the random effects assumed to have an Unstructured Covariance structure. Significance of the estimates was used as the main basis for model selection. Since each subsequent model was an expansion of the previous model, the simpler model was chosen if none of the added interaction terms were significant (stepwise model selection). Selected models are presented in the results.

For each participant, we also computed their treatment response variable in relation to global cognition (with an improvement of at least 0.5SD designated as a 'clinically meaningful' response to the intervention [30]) and to diabetes self-management (with an improvement of at least 1SD designated as a 'clinically meaningful' response).

Results

Sample characteristics, retention, & adherence

The flow of participants through the trial, including reasons for discontinuation, can be found in Figure 1. Demographic and adherence information of the sample can be found in Table 1.

Of the 85 participants who completed the baseline assessment, 76 (89%) returned for the post-intervention assessment and 70 (82%) were evaluated at the 6-months follow-up assessment. TA-CCT participants were more likely than the G-CCT participants to have completed the post-intervention assessment (100% versus 80%, $X^2(1, N=84)=9.73$, $p=.002$), as well as the follow-up assessment (93% versus 72%, $X^2(1, N=84)=6.45$, $p=.01$). No differences in measures of adherence or retention rates were found between participants assigned to the different SE conditions (Table 1). Means and standard deviations of all outcome variables by cognitive training condition, SE condition and time point are shown in Supplementary Table 1. Participants in the TA-CCT condition were slightly older than those in the G-CCT condition ($t(78.68)=2.11$, $p=.038$), but they did not differ on any other demographic characteristics or cognitive outcomes at baseline. There were also no differences on any demographic characteristics or baseline cognition between participants who completed all three assessments and those who did not complete post-intervention and/or follow-up.

Participants in the TA-CCT and G-CCT conditions were comparable in terms of overall compliance with the prescribed intervention, with 68% and 71% respectively completing at least 80% of the total prescribed sessions (n=48). However, participants in the TA-CCT condition spent more time training relative to the G-CCT condition ($t(79)=2.67$, $p=.009$). No differences were found between the SE conditions in the total time spent training.

Cognitive outcomes

Across training conditions, global cognition and both memory composite scores improved following the intervention, with further improvements observed at the follow-up assessment. The non-memory composite increased from pre- to post-training, which was retained at follow-up. However, these improvements were overall of similar magnitude in the two training conditions (Figure 2), and in the three SE conditions. The changes in global

cognition from baseline to post-intervention and follow-up were still significant when the analysis was repeated with training time as a covariate (baseline to post-intervention: β=0.22, stderr [standard error] =0.04, $p<.001$; post-intervention to follow-up: β=0.10, stderr=0.04, $p=0.007$). There was also an effect of total training time: participants who spent more time training had higher global cognition scores across all assessment points (β=0.0005, stderr=0.0002, $p=0.02$). The interaction between assessment occasion and total training time was not significant, i.e. a higher 'dosage' was not associated with greater improvements in global cognition. Beta estimates, associated standard errors and effect sizes of these results are shown in Table 2.

Fifteen people were defined as having lower baseline global cognition ($z\leq -0.5$) with the rest (n=68) defined as having average-high baseline global cognition ($z>-0.5$). Participants with lower baseline global cognition showed a greater improvement at the post treatment assessment relative to those with average-high baseline cognition (Cohen's d = 1.072), while participants with average-high baseline cognition improved to a greater extent between the post-intervention and follow-up assessments (Cohen's d = 0.367). No interaction was observed between baseline cognition, training condition and assessment occasion.

Secondary outcomes

Findings regarding diabetes self-management can be found below. Results concerning other secondary outcomes (meta-memory, mood outcomes, self-efficacy, activities of daily living and caregiver burden and distress) are provided in the *Supplementary Material*.

Diabetes self-management

Self and informant-reported diabetes self-management were strongly correlated at baseline ($r=0.68$, $p<0.01$). No association was found between self or informant-reported diabetes management and cognitive performance at baseline or at subsequent time points (all ps>0.05). Across conditions, self-reported diabetes-management improved at the post-

intervention assessment, and this was maintained at the follow-up assessment (Figure 1 and Table 2). No interactions between assessment occasion and either training or SE condition were observed. No change in informant-reported diabetes management was found at the different assessment occasions, and there were no interactions with any of the training or SE conditions.

Defining low baseline diabetes self-management as at least 1SD below the total sample mean (i.e. ≤ 5.49) on the DSMQ, 13 participants had low self-management (7 TA-CCT, 6 G-CCT). A Linear Mixed Model with baseline self-management (low vs. average-high) as a predictor showed an effect of both assessment occasion and baseline self-management on self-management outcomes, but no interaction. That is, participants with low self-management scores at baseline showed similar improvement in self-management as those with average-high baseline self-management scores and continued scoring lower than the rest of the participants at post-intervention and follow up.

Predictors of treatment response

Of the 75 participants who completed the post intervention assessment, 13 (TA-CCT=6, G-CCT=7) were found to have a 'clinically meaningful' improvement in cognition (improvement of 0.5SD or more in the global cognitive composite post-intervention). A logistic regression with gender, age, education, adherence, baseline cognition and baseline diabetes self-management showed that better global cognition at baseline was associated with being a non-respondent (B=-1.65, stderr=0.76, p=0.03), while being a female was associated with being a respondent (B=-1.90, stderr=0.87, p=0.03). No differences were found between respondents and non-respondents on diabetes self-management outcomes, and the association between post-treatment change on global cognition and change in diabetes self-management was weak and non-significant (r = -0.09, ns).

16 participants (TA-CCT=8, G-CCT=8) had a 'clinically meaningful' improvement in diabetes self-management (improvement of 1SD or more in self-reported DSMQ). A logistic regression with gender, age, education, adherence, baseline cognition and baseline diabetes self-management showed that lower baseline self-management (B=-0.63, stderr=0.28, *p*=0.03) and more years of education (B=0.28, stderr=0.12, *p*=0.03) were associated with being a respondent on the self-management outcome.

Discussion

This is the first report of the effects of multi-domain CCT on cognitive and non-cognitive outcomes in older adults at higher risk of dementia due to diabetes. We also investigated the effects of a secondary self-efficacy intervention in relation to adherence and disease self-management outcomes. Our findings join a growing body of evidence that has found benefits of CCT for cognitive outcomes in older adults without dementia [17]. Specifically, scores on a global cognitive composite, as well as performance in memory and non-memory cognitive domains improved following CCT, and benefits were either maintained or further improved at the six-month follow-up evaluation. Beyond objectively measured cognitive performance, participants in the current trial also reported greater use of everyday memory strategies at the end of the intervention period, and by the final follow-up assessment at six months post-intervention, participants have also reported fewer mood-related symptoms, particularly related to anxiety, relative to the study baseline possibly explaining the continued objective improvements six months after the end of the intervention (see Supplementary Materials). Importantly, the current trial was also the first to examine the effects of CCT on subjectively reported disease self-management, a cardinal feature of long-term outcomes in people with diabetes, and participants reported a modest improvement in self-management behaviors, which was maintained 6 months later. Importantly, this finding was limited to participants' self-report but was not replicated in the analyses of the informant-reported diabetes

management. Although informant-reported outcomes regarding the primary participant may have greater importance and reliability in some domains (e.g., mood and behavior), informant-report diabetes outcomes are likely to be less reliable in the context of the current study, as some informants did not reside with the primary participant or did not engage with them with a level of frequency to allow them to confidently rate some of the self-management behaviors, and indeed in many cases informants left some questions un-answered or stated having low confidence in their responses. Notwithstanding this limitation, the correlation between the self and informant-report self-management behaviors was strong (r=0.68), indicating high general agreement between the observations of the primary participants and the informants. We found no evidence in our analyses that improvement in self-reported diabetes management was more likely among participants who have shown a "clinically meaningful" improvement in global cognition (defined as an improvement of at least SD=0.5) or that change in global cognition and in self-report diabetes management were related. Hence, we are unable to draw a clear link between improved cognition and improved diabetes self-management at this point. However, in exploratory analyses (data not shown), in which a more lenient criterion for cognitive improvement was used (score greater than the post-treatment mean change of participants who completed less than 20% of the prescribed training, n=4, M=0.17), a small-to-moderate, but statistically non-significant effect (d=0.39, t(67)= -1.5, p=0.1) was observed suggesting that participants who showed at least modest improvement in global cognitive ability (n=45, M=7.4, *SD*=1.7) reported better diabetes self-management post-training relative to participants who did not show an improvement in global cognition (n=24, M=6.8, *SD*=1.3). Given the modest improvements in self-management reported by participants, the question of whether changes in cognition moderate CCT-induced improvements in self-management in diabetes remains to be adequately addressed in a larger trial.

In this trial, we compared outcomes between two types of CCT, one which was tailored to participants' cognitive profile and in which difficulty levels were adaptive, and a more generic CCT approach, in which tasks were not tailored and difficulty levels were fixed. Participants who were assigned to the tailored and adaptive condition spent more time training and were more likely to remain in the study, possibly reflecting greater motivation associated with maintaining a level of challenge. However, except for greater use of everyday memory strategies reported by participants in the TA-CCT condition, we found no evidence for an additional benefit associated with training in the tailored and adaptive condition in relation to objective cognitive outcomes. This finding is in keeping with other studies that compared adaptive and non-adaptive cognitive training conditions and found similar degree of overall cognitive improvement on both conditions in healthy older adults[31] and people with mild cognitive impairment [32], but contrasts with findings from other trials e.g., [30] in which tailored and adaptive training was superior to generic training. The reasons for this inconsistent finding are unclear, but more head-to-head trials comparing tailored and adaptive to generic forms of cognitive training within the same population are clearly needed to assess the degree to which these elements are critical for improvement on the trained and transfer tasks. It is however both interesting and encouraging that, across training conditions, participants with lower cognitive abilities at baseline improved at a greater rate than other participants by the end of intervention period and were more likely to demonstrate a "clinically meaningful" improvement in overall cognition. This observation, if replicated, has important implications as it suggests that cognitive training may be initially even more beneficial to those who's cognitive abilities are relatively low at the start of the intervention. Importantly, we found no differences between participants assigned to the three self-efficacy conditions, either in relation to adherence to the intervention, or in relation to measured outcomes. One possible explanation for this observation could be that the sample recruited for the current study was overall well educated and comprised of mostly high-functioning

individuals, who appear to have had relatively high levels of self-efficacy to begin with, making the detection of any improvement more difficult. Importantly, our SE intervention was exploratory, and our study was underpowered in relation to the analyses of interactions of time, training condition, and SE condition.

Limitations

We did not include a 'treatment as usual' condition based on the accumulated evidence from several systematic reviews that have supported the efficacy of cognitive training for cognitive outcomes in older adults without dementia [17,33] and the suggestion that the field should move on to trials focused on understanding of mechanism of action and head-to-head comparisons of different treatments, rather than focus merely on 'efficacy' [16,34]. Our trial design impedes ruling out the possibility that the observed improvements in cognition in both conditions are better explained by practice effects alone. Although retest and practice effects have likely contributed to the changes observed in participants' cognitive performance, several observations support the possibility that intervention-attributable improvements have also been observed, at least in part. First, as already noted, numerous studies have already demonstrated the efficacy of CCT in comparison to both passive and active control conditions. Second, effect size of the change in global cognition across conditions in the current study (d=0.495), as well as in the GCCT condition (d=0.83, data not shown) was significantly larger than the effect size associated with passive (d=0.12; CI=0.08-0.16) or active (d=0.18; CI=0.12-0.24) control conditions, as shown in a recent meta-analysis [35]. Third, we attempted to estimate the approximate improvement that might be expected from practice/retest alone in the current study by examining the mean improvement in cognitive composites in participants who did not adhere even to a minimal dose of the prescribed intervention (i.e., less than 20% of the total prescribed sessions, n=4). The effect estimate in this small group on the global cognitive composite at the post-intervention assessment was Cohen d=0.17, significantly lower than the mean improvement observed in the rest of the sample (Cohen d=0.49). Further studies

comparing tailored and adaptive CCT to generic forms are required to confirm our hypothesis that generic CCT is an active treatment condition associated with greater benefits than those associated with active control/placebo conditions.

Another limitation is related to characteristics of our sample, namely, the inclusion of predominantly highly functioning, well educated, and motivated community-dwelling older adults with diabetes. This self-selection may have led to both positive and negative bias in our findings. For example, participants in the current study might be more motivated and compliant in completing the training than the general diabetic population, limiting the generalizability of training effects if implemented on a wider scale. Nonetheless, our findings concerning the effect of training on cognition and self-management are encouraging considering this limitation, and effects may prove to be even stronger in lower functioning individuals. This possibility is also supported by our finding of a greater improvement in cognition by the end of treatment among those who had lower baseline cognition. Thirdly, although our sample was sufficiently powered to detect intervention-related differences between conditions on the main outcomes, it was insufficiently powered to detect more complex relationships, such as three-level interactions between training conditions, self-efficacy conditions, and assessment occasions. Finally, surrogate biological or physical health outcomes, such as hemoglobin A1c levels were not directly measured in this trial, although we plan on obtaining data from routine medical examinations from the partnering HMO (MHS) for further analyses and findings from these analyses will be reported in the future. Further work is required to examine the possible predictive or moderating role of diabetes-related health indicators on treatment outcome, as well as transfer of trained skills to everyday cognitive functioning, factors associated with treatment adherence and participant retention, and maintenance of benefits beyond the six months follow-up.

Conclusions

Older adults at higher dementia risk due to diabetes may benefit in the short to intermediate terms from home-based multi-domain computerized cognitive training in relation to their cognition, self-reported diabetes management, self-reported use of memory strategies, and symptoms of anxiety. A tailored and adaptive as well as a more generic version of the training seem to produce comparable results. Further work is required to better rule-out practice effects, establish or enable transfer of trained skills to day-to-day life, and understand the role of intervention parameters such as adaptive task difficulty and personal task tailoring in improving adherence. Computerized cognitive training represents an intervention that is relatively easy to implement in a range of community and clinical settings at relatively low cost, and given the encouraging findings in relation to cognition from large meta-analyses, future work exploring possible implementation strategies and barriers is warranted.

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Table 1. Background information of the whole sample, as well as split by condition and SE group.

	Total	TA-CCT group	G-CCT group	Global SE group	Domain SE group	No SE group
N	85	44	40	29	29	26
Age	71.45 (4.85)	72.41 (5.37)*	70.25 (3.95)*	70.76 (4.71)	70.83 (5.06)	72.69 (4.65)
Sex (male)	51 (60%)	28 (64%)	23 (57%)	17 (59%)	16 (55%)	18 (69%)
Years of education	16 (2.99)	15.77 (3.15)	16.25 (2.86)	16.14 (2.89)	15.31 (2.52)	16.64 (3.56)
Completed post-intervention assessment	76 (89%)	44 (100%)**	32 (80%)**	26 (90%)	26 (90%)	24 (92%)
Completed follow-up	70 (82%)	41 (93%)*	29 (72%)*	24 (83%)	24 (86%)	21 (81%)
Completed booster[1]	36 (53%)	21 (55%)	15 (50%)	11 (50%)	14 (56%)	11 (52%)
Completed ≥80% of the prescribed training dose (i.e. ≥ 39 sessions)	56 (67%)	30 (68%)	26 (65%)	18 (62%)	20 (69%)	18 (69%)
Number of sessions completed	39 (17)	41 (15)	36 (19)	36 (18)	40 (17)	42 (16)
Number of minutes spent on training	489 (244)	553 (244)**	412 (225)**	432 (238)	505 (249)	540 (243)

Note. numbers are means with standard deviations between brackets unless specified otherwise. TA-CCT=tailored adaptive computerized cognitive training, G-CCT=generic computerized cognitive training, SE=self-efficacy.

[1]Percentages are calculated out of those invited for the booster.

* p<.05, ** p<.01.

Table 2. Betas, standard errors and Cohen's d effect sizes of the effect of time and difference between conditions in change over time in the cognitive measures and diabetes self-management.

	Baseline to post-intervention				Post-intervention to follow-up			
	Time		TA-CCT vs G-CCT		Time		TA-CCT vs G-CCT	
	β (stderr)	Cohen's d	β (stderr)	Cohen's d	β (stderr)	Cohen's d	β (stderr)	Cohen's d
Global cognition composite	**0.23 (0.03)**	**0.495**	-0.09 (0.07)	-0.317	**0.10 (0.04)**	**0.207**	0.11 (0.07)	0.364
Delayed memory composite	**0.35 (0.05)**	**0.540**	-0.26 (0.11)	-0.533	**0.17 (0.06)**	**0.271**	0.11 (0.11)	0.246
Memory and learning composite	**0.35 (0.06)**	**0.494**	-0.12 (0.13)	-0.220	**0.28 (0.07)**	**0.404**	-0.13 (0.13)	-0.293
Non-memory composite	**0.08 (0.03)**	**0.189**	0.05 (0.06)	0.235	0.03 (0.03)	0.071	0.04 (0.06)	0.061
Diabetes self-management (self-report)	**0.40 (0.13)**	**0.249**	-0.22 (0.26)	-0.211	-0.15 (0.14)	-0.098	0.25 (0.28)	0.152

Note. positive effect size indicates increase over time, or more positive change in TA-CCT group. TA-CCT=tailored adaptive computerized cognitive training, G-CCT=generic computerized cognitive training, stderr=standard error. Numbers in **bold** indicate significance at $p<.05$.

Figure 1. Participant flow chart.

Figure 2. Change in global cognition and diabetes self-management for both conditions. TA-CCT=tailored adaptive computerized cognitive training, G-CCT=generic computerized cognitive training.