ORIGINAL RESEARCH

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The Efficacy of the Computer-Based Multi-Domain Cognitive Training Program on the Cognitive Performance of Healthy Older Adults: A Pilot Randomized Controlled Study

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Abstract

Objective: There has been great interest in using computer-based cognitive training (CBCT) to prevent or reduce pathological and normal age-related cognitive decline. This study was carried out to examine the efficacy of a CBCT program on the cognitive functions of healthy older adults. An online CBCT program provided exercises for five cognitive domains.

Materials and Methods: In a randomized controlled trial, the experimental group (EG) (EG, n=28) implemented CBCT while the comparison group (CG) (CG, n=31) was given standard services. Participants completed approximately 30-minute sessions over the course of eight weeks for a total of 24 sessions. Data were collected using the mini mental state examination, Oktem Verbal Memory Processes test (OVMPT), Wechsler Memory Scale-Revised (WMS-R) Visual Reproduction Subtest, WMS-R digit span forward and backward tests, verbal fluency tasks (category and phonemic), Stroop test Çapa form, Trail Making test (TMT) (part A and B), Benton Judgment of Line Orientation test (JLO), Benton Facial Recognition test, and the 15-item version of the Boston Naming test. The data were examined using number, percentage, arithmetic mean, chi-square test, Mann-Whitney U test, Paired Sample t-test, and Wilcoxon test.

Results: The EG showed greater improvements than CG on verbal memory (OVMPT, z=-3.386, p=0.001) and effect was moderate (r=-0.4524). EG significantly improved simple attention in WMS-R digit span forward (z=-1.995, p=0.046) with a low effect (r=-0.2665). EG showed significantly differences in verbal fluency tasks (category: z=-3.152, p=0.002, phonemic: z=-2.859, p=0.004) with low effects (r=-0.4212, r=-0.3820, respectively) and set shifting (TMT A: z=-2.906, p=0.004) with low effect (r=-0.3883). The EG group improved visuospatial functions for JLO (z=-2.894, p=0.004) with moderate effect (r=-0.3867).

Conclusion: It is recommended that CBCT can be used for improving several cognitive domains of healthy older adults.

Keywords: Cognitive training, healthy older adults, aged

Introduction

The number of older adults is increasing at an unprecedented rate globally, and the prevalence of age-related cognitive decline, as well as that of neurodegenerative diseases such as dementia, is rising correspondingly. When taking into account the physical, psychological, social, and economic effects (1), it is becoming increasingly important to promote successful entire-lifetime cognitive aging to maintain or improve brain health and cognition (2), and in particular, to identify and assess strategies that support healthy cognitive aging (3). Studies on humans and animals demonstrate that the brain is capable of neuroplasticity even in later life (4). Over the past decade, cognitive training (CT) has drawn more scientific attention, due to its promising approach to enhancing cognitive functions and preventing or

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delaying cognitive deterioration in old age (5). A striking study found similar results for the extent and nature of CT benefits for both older (50-80) and younger (18-49) participants (6). This metaphor's underlying idea is that repeated activation of brain regions causes a variety of changes, a process known as neuroplasticity, both at the cellular and larger network levels (7,8). Furthermore, CTs provide easy facilitation into daily routines, and are cost-effective (9). Researchers have given significant consideration to both traditional activities and novel interventions due to their potential to prevent cognitive decline or its effects through cognitive engagement (6). The methods and formats used in CTs vary depending on factors such as the modality [paper-pencil (traditional) vs. computer-based], setting (individual vs. group), or the number of targeted domains (single vs. multi-domain training) (10). Multi-domain CTs target at least two cognitive domains, while single-domain CTs focus on a single cognitive function, which could be memory, executive functions, attention, visual-spatial functions, or language. The former rather than the latter has been recommended for improving cognition in healthy older adults (11).

Computer-based cognitive training (CBCT) aimed at preventing and reducing cognitive impairment has emerged as a result of technological advances in information and communication. Many of these programs offer significant benefits. They allow for an individualized approach based on each person's needs and characteristics, are more accessible because they avoid problems associated with limited mobility and/or access to health resources, have a lower economic cost, and permit objective performance evaluation and immediate feedback (12-14). A meta-analysis examining the effectiveness of CBCTs found that the outcomes varied depending on the targeted cognitive domain and the training program used (15). A number of studies have found that cognitive performance improves after interventions, but others have not, and questions remain about the efficacy of specific CT interventions (16). With the rapid increase in the number of commercially available CBCT programs in recent years, the evidence for these commercial products, while promising, is limited and uncertain. More research is needed to better understand the effectiveness of CBCT on cognitive functions (17). This pilot study is the first study, to our knowledge, to investigate the effectiveness of a computer-based multi-domain CT program progressively challenging on the cognitive performance of healthy older adults in Türkiye. We believe that a pilot study this is required to detect potential study failures or issues, and to limit the likelihood of squandering time, effort, and money on a larger population investigation. We hypothesized that using the program known as "MentalUP" would improve cognitive abilities compared to the control, as measured by a battery of neuropsychological tests. This improvement may provide information on the use of CBCT in healthy older adults, helping such individuals gain the greatest possible benefits for health promotion and disease prevention.

Materials and Methods

Participants

Participants were recruited from Narlıdere Residential and Nursing Home, affiliated with the İzmir Provincial Director of Family and Social Services. The institution's capacity is 678 people in the healthy older adult blocks and 269 in the geriatric care center. Participants in the study were healthy older adults. Those in the healthy older adult blocks undergo cognitive [mini mental state examination (MMSE), clock drawing etc.] and physical assessments (activities of daily living, timed up and go test etc.) every six months. Those who do not meet the healthy older adult criteria are referred to the geriatric care center. The following requirements must be met in order to live in these blocks: being capable of performing daily living activities independently; having no psychiatric disorder that could endanger themselves or others; having no infectious disease; and having no addiction to alcohol or drugs (18). The following were the study's inclusion criteria: age 65 to 84, a mini-mental state examination score of ≥23, the ability to speak Turkish fluently, having basic computer skills, the absence of hearing or vision problems (institution records as well as the older people's self-report), and educational level ≥5 years. The exclusion criteria were: usage of antipsychotics, antidepressants, antiepileptics, or acetylcholinesterase inhibitors; color blindness or color vision deficiency; hearing and vision problems; and a diagnosis of hypothyroidism, stroke, transient ischemic attack, and/or traumatic brain injury.

Study Design and Procedure

This study was conducted as a single-blind, prospective, randomized control trial with a pre-post, and comparison group (CG) between March 2018 and March 2020. Using the Random Integer Generator method from random.org, single-group numbers between 1 and 70 were produced, and the older adults were then randomly assigned to these groups (https://www.random.org/integers/?num=70&min=1&max=2&col=1&base=10&format=html&rnd=new). Following the drawing of lots, lot number 1 was assigned as the CG and the lot number 2 as the experimental group (EG); the EG received training through the computer-based online multi-domain CT program, while the CG received no form of intervention. Group assignments were made based on participant arrival order. The participants were not informed about which group they were in, but the researchers were aware. During this time, participants were given reminders about training days. Throughout the CBCT program, all participants used the institute's room and a desktop computer with a 21.5-inch screen. The program was scheduled in line with participants' preferences. A nurse was in the room during the exercise process. Participants who found that they were unable to attend at the specified time and date were later contacted to arrange a new schedule. Figure 1 shows a CONSORT flow diagram of the study.

Cognitive Training Program

MentalUP was used as the CBCT program since it is simple to use, easy to access, and available in not only Turkish but also German, English, Portuguese, and Spanish. The website or the application can be used to access MentalUP, an internet-based program, via a computer or a mobile device. MentalUP is a participant of the University College London Institute of Education EDUCATE Program (19). The program requests a username and password; therefore, each participant was given an anonymous user ID number and password. No personal information was recorded. It was originally designed primarily for children, but the adult version was used in this case. Prior to commencing the program, users select the appropriate level from children's age groups, and a separate adult version. The purpose and target population of the study had been previously explained during interviews with developers of the program. They explicitly stated that the adult version was appropriate for older adults. As far as we know, Other similar commercial games only have versions designed for adults in general, rather than specifically older adults. EG participants received the same training experience (adult version) as MentalUP subscribers over the same time period. MentalUP automatically records the accuracy and failure rate. The game advances to the next level after achieving a critical level of performance. Additionally, two features are provided to encourage participant participation. An avatar is displayed at the outset of the activities as a guide who explains the objectives and steps of the exercises. The aim is to reduce anxiety about engaging with the program. Users are rewarded for their performance at the conclusion of each exercise with one, two, or three virtual stars. This type of feedback fosters competitiveness and a sense

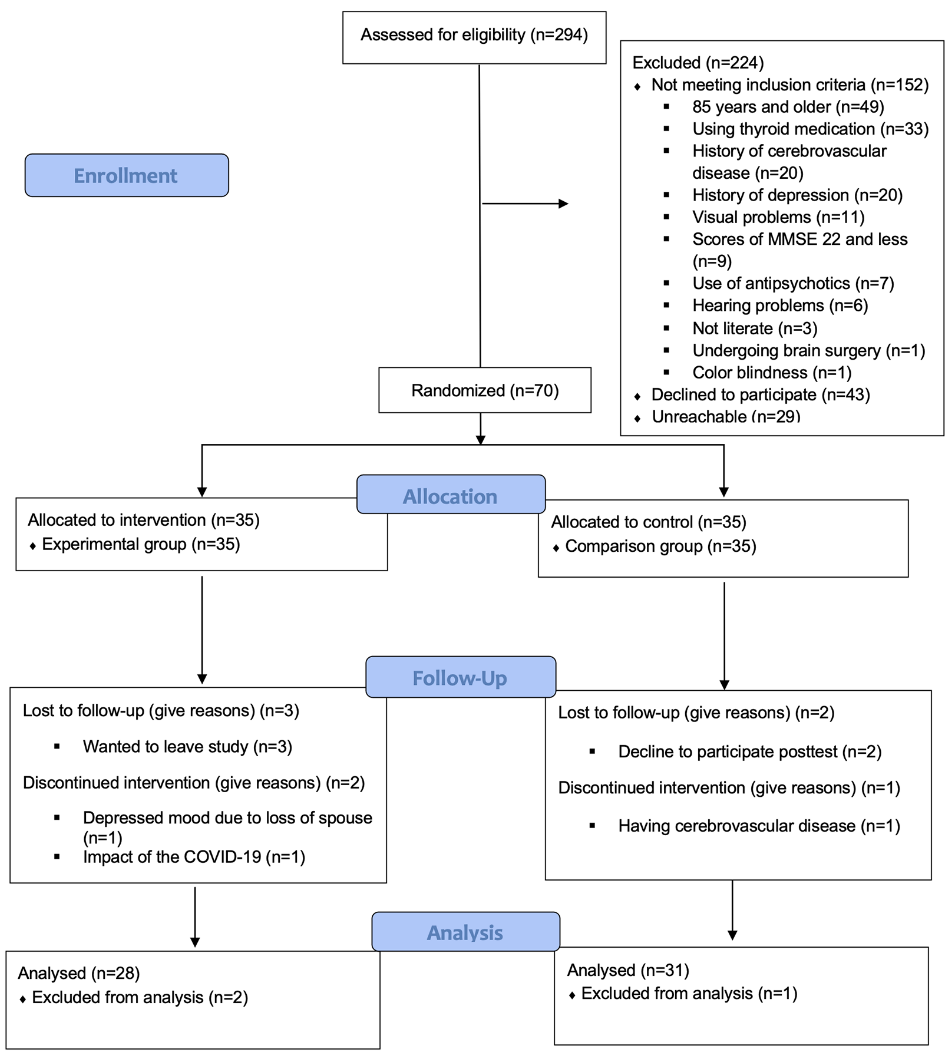

Figure 1. Flow diagram of the participants in the study

MMSE: Mini mental state examination

of accomplishment. The daily exercise consisted of ten games covering five cognitive domains. An algorithm chooses the ten games for each training session on any given day, attempting to optimize a balance of training activities. The daily training program comprises a total of 10 games. Depending on the response times, the whole duration could range from twenty to thirty minutes. During each of these sessions, different tasks are carried out, assessing memory, attention, executive functions, visual-spatial functions, and language (19). CBCT programs are designed to encourage constant effort and help people extend their cognitive abilities (20). This provides individuals with motivation to continue (21). It also has the advantage of being adaptable in terms of training and allowing for the systematic development of cognitive abilities that may be weaker than others (21,22). This was an important component of the CBCT program used in the current study. Players who outperformed the average in the current game were able to raise the level. Furthermore, there were opportunities to get more practice in the area(s) where they were weaker. Following each game, participants had the possibility to assess their own performance and progress. Figure 2 shows some of these tasks.

Intervention

The computer-based multi-domain online CT program consisted of a total of 24 sessions over 8 weeks for the participants assigned to the EG, while the control group continued to receive standard care. The optimal intensity for CT is 30 minutes per session, with three sessions per week being optimal (23). The program gives

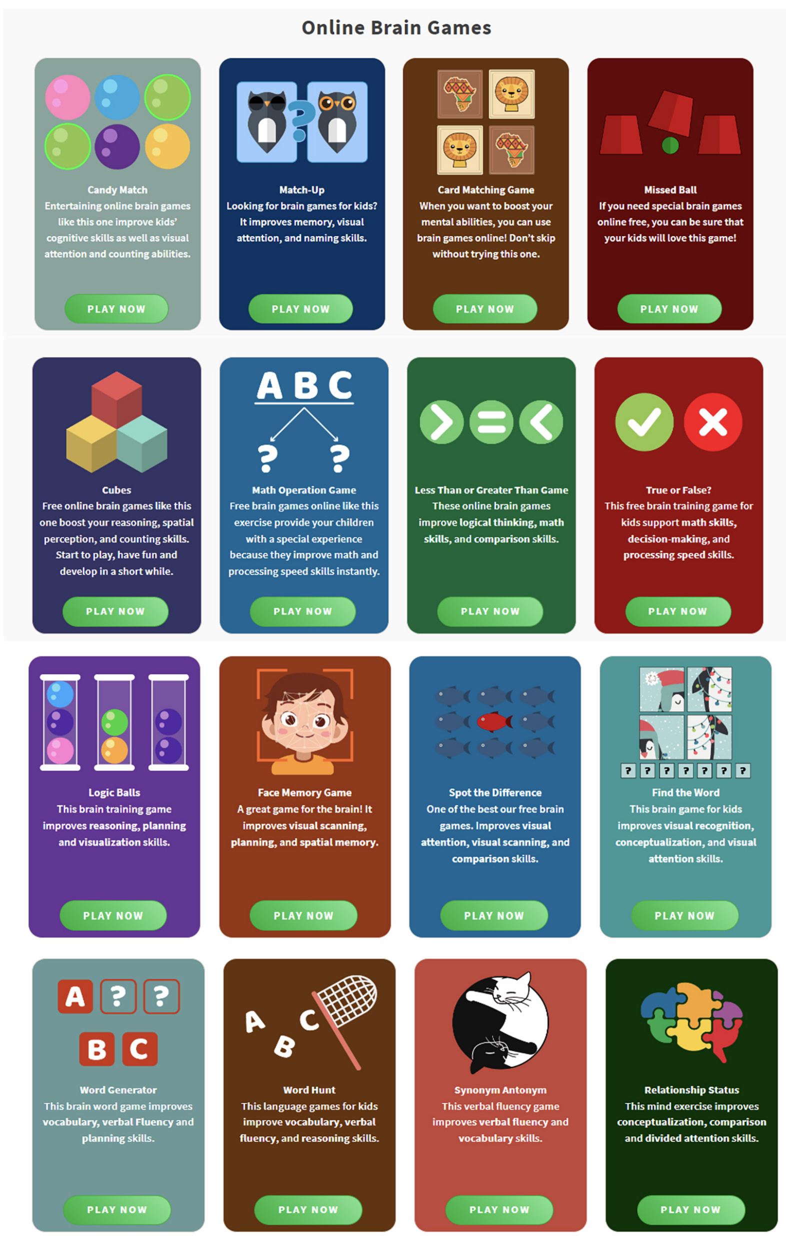

Figure 2. Some of the MentalUP games

participants brief instructions on how to complete each exercise before they begin. After a familiarization period, participants began to play and received access to their initial score, any gains they made, as well as the average score for their age group. To reduce retest effects, counterbalanced parallel forms of the Oktem Verbal Memory Processes test (OVMPT) were used.

Outcome Measures

A neuropsychologist administered a comprehensive battery of neuropsychological tests to all individuals.

Global Cognition and Memory

The MMSE test was used to evaluate global cognition. It consists of items for orientation, working memory, memory recall, language, concentration, and (24). The MMSE scores range from 0 to 30, and higher scores indicate greater cognitive function. The Turkish version of the MMSE demonstrated adequate psychometric properties for the diagnosis and screening of dementia in an older Turkish population living in the community (25).

OVMPT, which measures both immediate and delayed recall, was used to assess verbal episodic memory. It involves recall of a 15-item word list that is read aloud ten times (26).

The Wechsler Memory Scale-Revised (WMS-R) was used to evaluate visual episodic memory (immediate and delayed recall) visual reproduction subtest, which consists of 3 cards and 4 shapes (27,28).

Attention

WMS-R digit span forward and backward tests were used to assess attention. This involves participants repeating a series of numbers in the same order (forward), followed by another series of numbers in the reverse order (backwards) (29,30).

Executive Functions

Verbal fluency tasks (category and phonemic) (31,32), the Stroop test, and the Trail Making test (TMT) (part A and B) were used to evaluate executive functions. The Stroop test is used to examine executive functions, which measure selective attention, speed of information processing, response inhibition, and cognitive flexibility (33,34). TMT has two sections. Drawing lines sequentially linking circles with consecutive numbers from 1 to 25 in part A of the test is a visual scanning task; part B of the task measures cognitive flexibility by connecting the same number of circles with an alternating sequence of numbers and letters (35,36).

Visuospatial Functions

The f of Jordan Line Orientation test (JLO) (37) and the Benton Facial Recognition test (BFRF) (38) were used to assess visual-spatial abilities. The JLO test evaluates the accuracy of angular orientation based on perceptions of a pair of angled lines, which visually resemble another pair that is encircled by an 11-line semicircular array (39). The BFRF assesses perceptual discrimination as well as the ability to identify and distinguish photographs of unfamiliar faces with non-emotional/neutral expressions. Validity and reliability studies were conducted for Türkiye by Karakaş (40) and Keskinkılıç (41), respectively.

Language

The Boston Naming test, a 15-item version, was used to assess language (42). The participant is asked to name drawings of 15 objects.

Sample Size

G*Power 3.1 was used to calculate the sample size. With 80% power and an alpha of 0.05 (two-sided), each group needed a minimum of 22 participants (43). A total of 70 participants (35 per group) were recruited and allocated to either the experimental or CG.

Statistical Analysis

All data were analyzed with SPSS statistical package version 22.0 (SPSS Inc., Chicago, IL). The Kolmogorov-Smirnov test was used to determine whether the data were normally distributed. Numbers, mean, and standard deviation were used in descriptive statistics. Percentage was used to evaluate the descriptive characteristics of the older adults, while the Mann-Whitney U test and chi-square test were used to compare the characteristics of the individuals in the experimental and CG. The Wilcoxon test was performed to compare the pre- and post-test mean scores of the EG. A paired t-test was used to compare the mean scores of the CG for the pre- and post-test. To assess the effectiveness of the computer-based CT program, the effect size (r) was calculated ($r=Z/\sqrt{N}$) (44). The effect size is interpreted as 0.20 for a small effect, 0.50 for a medium effect, and 0.80 for a large effect. The statistical significance level was determined as $p<0.05$.

Ethical Consideration

The Dokuz Eylül University Non-Interventional Clinical Research Ethics Committee approved the study (approval number: 2017/27-44, date: 23.11.2017). Narlıdere Residential and Nursing Home, affiliated with the İzmir Provincial Director of Family and Social Services, provided institutional permission. People who were interested in the study were initially provided with standardized information, including the aim of the study, a timeline, and a brief explanation of the neuropsychological assessment. Participants' suitability for the study was confirmed via interview and MMSE cognitive screening, and a signed written informed consent form was obtained before the first neuropsychological assessment. A specialist psychologist, assessed the baseline and follow-up neuropsychological testing.

No payment was made to participants. The researchers obtained MentalUP at no cost. The founders and partners of MentalUP offered free access to their CBCT program for research purposes. However, no one connected to the commercial program was present during any of the project's stages: study design, data analysis, or decision to publish.

Results

The descriptive statistics between groups are shown in Table 1. No significant differences were found in the baseline data, which included sociodemographic factors such as age (p=0.903), education years (p=0.489), and sex (p=0.859). There were no significant baseline differences between the groups in the neuropsychological test mean or the standard deviation.

Within global cognition, neither group improved significantly (EG: z=-1.269, p=0.204; CG: t=0.769, p=0.448). In the EG, outcomes for memory tests were consistently better after the posttest, whereas in the CG, they were inconsistent. In the EG, significantly higher values post-test compared to pre-test were found in verbal immediate recall (OVMPT, z=-3.386, p=0.001), and the effect was moderate (r=-0.4524). Within the domain of attention, EG significantly improved in WMS-R digit span forward (z=-1.995, p=0.046), with a small effect size (r=-0.2665). Within the domain of executive functions, EG showed significant differences in verbal fluency tasks (category: z=-3.152, p=0.002, phonemic: z=-2.859, p=0.004) with low effects (r=-0.4212, r=-0.3820, respectively) and set shifting (TMT A: z=-2.906, p=0.004) with a low effect (r=-0.3883). The EG group improved visuospatial functions for JLO (z=-2.894, p=0.004) with moderate effect (r=-0.3867), while there were no significant differences between groups for BFRF pre- and posttest scores. With regard to language pre- and posttest findings, there were no noticeable changes between the groups (Table 2).

Discussion

There has been a considerable amount of interest in using CBCT to maintain or enhance older people's cognitive functions. The focus of this study was to compare the effect of a multi-domain CBCT program with that of an untrained control group on the cognitive performance of healthy older adults. The findings revealed that MentalUP had an immediate positive effect on certain cognitive domains in cognitively healthy older adults.

The training program had no significant effect on global cognition scores (45-47). In these studies, older adults worked out five days a week for four to twelve weeks for 15 to 90 minutes each time. In contrast, Active Mind, a local Chinese CT program (providing eight 1-hour sessions of CT), was shown to be effective in improving global cognition (48). However, it should be noted that different measurement tools were used in these studies. Also, the current Cochrane review stated that, in the aforementioned study, evidence on global cognitive function at the end of the trial was of low quality, and the study was characterized by imprecision and risk of bias. The study stated that there was only low-quality evidence indicating that after 12 weeks of training, CBCT might slightly enhance global cognitive function in comparison to an active control (49). In addition, it should be noted that in our study, the baseline global cognitive scores of the individuals participating were higher. There is a phenomenon known as the "ceiling effect", when the post-test cannot be increased because the already very high pre-test global cognition scores of a large portion of study participants (50). When cognitive baseline performance is low, improvement in cognitive domains is more likely (11). Therefore, this ceiling effect may partially explain our findings.

The finding that verbal immediate recall showed significant improvements in the EG provides support for the efficacy of CBCT in healthy older adults in the short term. Studies showed that CT can improve the performance of verbal immediate recall in trained groups (51-53) (30 to 90 minutes' sessions, four-five days a week, for one to twelve weeks); but other studies note no improvement (11,47,54). The majority of the memory games in the MentalUP training program focused on immediate recall. Garcia-Campuzano et al. (55) observed that the CT program for improving memory performance enhanced verbal delayed recall (30-minute sessions, three times per week, for 8 consecutive weeks) (55). According to the current Cochrane database of systematic review, there is low-quality evidence indicating that CBCT may marginally improve episodic memory in comparison to an inactive control. Reportedly, a 12-week CT program improves immediate recall, but no studies have shown substantial evidence demonstrating improved delayed recall (49). There was no statistically significant difference in delayed recall in our study, even though the CT program sessions was a similar intensity as in Garcia-Campuzano et al. (55) This may be because the CBCT program utilized in this study has fewer

Table 1. The demographic characteristics of groups

	Experimental (n=28)	Comparison (n=31)	Test value	p
Age	75.10±5.87	75.16±5.37	MWU=426.000	0.903
Education (years)	11.50±3.19	12.19±2.28	MWU=389.500	0.489
Sex (F/M)	16/12	17/14	x^2=0.032	0.859

MWU: Mann Whitney U test, x^2: Pearson chi-square test, F/M: Female/Male tasks for delayed recall memory, and thus may be ineffective in improving older adults' performance in this area.

On visual episodic memory measures, individuals in the CBCT group performed no better than those in the CG group, consistent with the findings of Oh et al. (47), who found that CT has no statistically significant effects on visual episodic memory. In contrast to our findings, Kalbe et al. (11) found a statistically significant difference in long-term visual memory mean scores after 12 hours of CT. This disparity could be explained by the fact that participants in that study had lower visual memory scores than participants in our study. Cognitively healthy people can use CT programs to enhance their weaker cognitive functions, but individuals with higher cognitive performance may need more challenging and intensive training programs to maximize their cognitive functions.

The study results showed significant effects on the participants' simple attention scores after CBCT. The current study's findings, which show that CT has an effect on simple attention, are consistent with those of Buitenweg et al. (51). On the other hand, CT has been shown to have no effect on simple attention in another study (43). In the last-mentioned study, the program was implemented for 15 minutes five days a week for four weeks (5 hours in total). This study's training period was shorter, which may have contributed to participants' attention scores remaining constant.

In healthy older adults, CBCT has been shown to improve executive functions. The findings of our study are consistent with previous research (60- to 75-minute session, two to four days a week, for two to eight weeks) (53,56). Contrary to our research, some investigations have demonstrated that CT has no impact on phonemic and semantic fluency (11,51). However, a

Table 2. Pre-/Post-test comparison of test performance in both groups

	Experimental (n=28)			Comparison (n=31)		
	Pretest	Posttest	Test value, p	Pretest	Posttest	Test value, p
Global cognition						
MMSE	28.64±1.16	28.96±0.83	z=-1.269, 0.204	29.12±0.99	29.03±0.98	t=0.769, 0.448
Memory						
Verbal episodic memory						
Immediate recall OVMPT	5.10±1.39	6.17±1.44	z=-3.386, 0.001*	5.61±1.25	5.67±0.90	t=-0.373, 0.712
Delayed recall OVMPT	10.82±2.10	11.25±1.75	z=-1.403, 0.160	11.38±1.99	11.03±1.74	t=-1.688, 0.102
Visual episodic memory						
Immediate recall WMS-R	8.42±3.37	8.89±2.45	z=-1.250, 0.211	8.35±3.19	8.61±2.57	t=-1.114, 0.274
Delayed recall WMS-R	7.46±3.96	8.03±3.07	z=-1.685, 0.092	8.48±3.41	8.80±3.07	t=0.952, 0.349
Attention						
WMS-R digit span forward	5.10±1.09	5.46±0.63	z=-1.995, 0.046*	5.19±0.87	5.03±0.54	t=1.541, 0.134
WMS-R digit span backward	3.71±0.80	3.89±0.68	z=-1.291, 0.197	3.70±0.86	3.58±0.71	t=-1.438, 0.161
Executive functions						
Stroop D	54.85±18.83	51.28±13.61	z=-1.283, 0.199	60.29±22.55	59.83±21.28	t=0.234, p=0.816
Verbal fluency tasks						
Category	19.35±3.64	21.32±3.64	z=-3.152, 0.002*	20.74±4.75	21.19±3.63	t=-0.980, 0.335
Phonemic	37.42±10.51	40.42±9.11	z=-2.859, 0.004*	37.20±9.43	38.80±8.97	t=-1.461, 0.154
Information processing speed						
TMT A	59.28±28.63	51.85±20.01	z=-2.906, 0.004*	52.03±13.92	51.16±10.86	t=0.645, 0.524
Set Shifting						
TMT B	127.57±50.84	121.60±51.07	z=-1.732, 0.083	122.35±35.37	118.29±28.89	t=1.198, 0.240
Visuospatial functions						
JLO	20.50±3.37	21.39±2.64	z=-2.894, 0.004*	19.93±3.26	20.25±3.10	t=-1.718, 0.096
BFRF	44.21±4.30	44.64±4.06	z=-0.920, 0.358	45.35±3.95	44.70±3.85	t=1.470, 0.152
Language						
BNT	14.28±0.97	14.42±0.83	z=-1.414, 0.157	14.22±0.80	14.32±0.70	z=-1.000, 0.325

* $p<0.05$
MMSE: Mini mental state examination, OVMPT: Oktem verbal memory processes test, WMS-R: Wechsler memory scale-revised, TMT: Trail Making test, JLO: Benton Judgment of Line Orientation test, BFRF: Benton Facial Recognition test, BNT: Boston Naming test, z: Wilcoxon test, t: Paired Samples t-test

CT program may help with verbal fluency, specifically phonemic fluency, which is a well-known executive function (53). Phonemic fluency is thought to more accurately reflect executive functioning because participants are required to list the words according to a rule that goes against the natural organization of words in the brain (56). According to the current Cochrane database of systematic reviews, low-quality evidence suggests that, when compared with an inactive control, CBCT may have little or no effect on executive function, working memory, or verbal fluency (49). A possible reason is that the CBCT program (MentalUP) contains numerous words and categories. The repetition of similar words is thought to help participants learn them and enhance their verbal fluency test scores. For example, words found during the "word hunt" exercise recur during the "wise owl" and "ripped words" exercises. Furthermore, natural intelligence allows repetition and learning of the names of animals and flowers.

The participants in the EG had statistically significant improved information processing speed scores after CBCT. The current study's findings support previous research (46,47,51,56-58). However, studies have shown that CT has no effect on information processing speed (11,53,54). According to the current Cochrane database of systematic reviews, the quality of the evidence on processing speed was very low (49). One of the primary goals of CT for older people should be to improve these functions (47), given that both executive functions and information processing speed decline with age (59,60), and that these functions are linked to daily life activities (61).

In this study, JLO and BFRF were used to assess visuospatial functions. Following CBCT, the JLO scores of those in the EG increased significantly, whereas the BFRF did not differ. According to Kalbe et al. (11), CT had no statistically significant effect on visuospatial function test scores because in the CBCT, there was no exercise designed to enhance the perception of faces. This was believed to be the reason for the lack of statistically significant change in the BFRF scores.

Language scores did not differ significantly, and we could not find any CT study that included this test in outcome measures. Despite the fact that the MentalUP contains exercises to name objects, there was no improvement; this could be due to the ceiling effect (high baseline scores) the ease of the exercises. Those with lower language scores may need more challenging tasks.

Study Limitations

This study had some limitations that needed to be noted. One of the study's shortcomings is the lack of follow-up measurements to determine whether the effects were maintained after the CBCT had ceased. Mood and general affectivity may have an effect on cognitive functions by the MentalUP program. These potential factors were not taken into account in evaluating our program. Another possible limitation of the study is the lack of an active control group. Additionally, this study was single-blind. In some cases, parallel forms of a particular neuropsychological test are utilized in the literature to reduce the learning effect on tests. However, only the parallel forms (A and B forms) of the OVMPT were employed in this study. There are no Turkish parallel versions of other tests. Finally, CBCT programs may be useful for enhancing the weaker cognitive domains of healthy people. High cognitive performers might benefit from more challenging training programs to maximize their functions. We believe that by extending CT protocols, these weaknesses may be overcome, in light of this.

Recommendations for Future Research

The specific strength of the current study is that it is the first to our knowledge that examines the immediate effectiveness of a computer-based multi-domain CT program on the cognitive performance of healthy older adults in Türkiye. MentalUP implemented in our research allows for the use of German, English, Portuguese, Turkish, and Spanish. Further studies can be carried out in countries where these languages are spoken, taking into account the following key points. We suggest that further studies be carried out with a larger sample size, longer follow-up, and double-blind design. Since only a passive control group was used in this study, future studies should employ both active and passive control groups to gain deeper insight into the changes in cognitive functions enabled by the implementation of CBCT. Additional possible predictors that influence multi-domain CT gains are sociodemographic variables (i.e., age, sex, and education), further psychological variables (i.e., quality of life, depression), genetic variables (i.e., apolipoprotein E4), functionality (i.e., activities of daily living), brain imaging measures, and EEG markers. Future studies may also take these variables into account. Effects of multi-domain CT interventions could be observed in trained tasks in healthy older people, and also, transfer effects in untrained tasks. Another area for study is the assessment of the transfer of improvements in participants' daily living activities or functional results in social participation.

Conclusion

Health professionals have great responsibilities in determining the needs of older people and providing appropriate care. Because of the importance of cognitive functions, cognitive activities should be incorporated into the care of the elderly, in order to maintain and improve them. The promotion of positive neuroplasticity in older adults can enhance their cognitive reserve and functions. Health professionals can inform them and their families about CBCT programs to encourage their utilization. Despite the limitations of the current study, the findings of this study indicate that 24 sessions over the course of 8 weeks of computer-based multi-domain online CT program can lead to measurable improvements regarding the immediate positive effects in some cognitive domains in cognitively healthy older adults. The findings further support the findings in the literature that this CBCT program, marketed under the brand-name MentalUP, could be used to support cognitive functions in older adults, and could function as a trial protocol for intervention by health professionals, especially by nurses. Also, it is simple to administer and not overly expensive, which makes it a potentially useful tool in any strategy to support healthy cognitive aging in older adults.

Ethics

Ethics Committee Approval: The Dokuz Eylül University Non-Interventional Clinical Research Ethics Committee approved the study (approval number: 2017/27-44, date: 23.11.2017).

Informed Consent: Informed consent was obtained from the older people included in this study.

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Note

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Footnotes

Authorship Contributions

Concept: M.A.A., Ö.K., A.T.I., G.Y., Design: M.A.A., Ö.K., A.T.I., G.Y., Data Collection or Processing: M.A.A., Analysis or Interpretation: M.A.A., Literature Search: M.A.A., Ö.K., A.T.I., G.Y., Writing: M.A.A., Ö.K.

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