The effects of computer-based cognitive training program on reaction times of patients with early stage Alzheimer's disease and traumatic brain injury

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ABSTRACT

Objective: Computer-Based Cognitive Training Programs (CBCT) are considered to be effective both in reducing cognitive deficits in the process of Alzheimer's disease (AD) and the treatment of cognitive dysfunction in patients with traumatic brain injury (TBI). This research aimed to investigate the effects of this program on reaction times of AD and TBI patients and to evaluate its applicability for patients with various levels of cognitive dysfunction.

Material and Methods: The data of patients with early-stage Possible AD or TBI who had at least 20 sessions of the CBCT program because of cognitive dysfunctions were evaluated retrospectively. The age, gender, educational status, marital status, systemic diseases, family history for dementia, and disease duration of the patients were recorded. NoroSOFT® Cognitive Training Program was applied to all participants three days a week for eight weeks. The patients' total scores, total accuracy percentages, and total levels as well as the reaction times of all patients in the first and last session of their performance, were determined at the end of the program.

Results: In this study, the data of 31 patients [17 Traumatic Brain Injury (54.8%), 14 Early-Stage Alzheimer's disease (45.2%)] who completed the CBCT Program were analyzed. The mean age of Alzheimer's patients was 73.28 ± 4.89 years, and the mean age of TBI patients was 30.94 ± 12.24 years. The reaction times at the end of the program were significantly better in both groups than before (in TBI;14.55 ± 7.32 sec, 7.23 ± 3.07 sec p<0.01 / in AD; 13.43 ± 6.90 sec, 9.48 ± 3.55 sec p<0.01). Total memory scores were found to be significantly better in patients with TBI than in patients with AD (1404.64 ± 435.87 points, 932.47 ± 503.06 points p=0.01, respectively) at the end of the program. There was no drop-out of the patients and no side effects were reported during the program.

Conclusion: CBCT programs are easily applicable and sustainable interventions in the patients with TBI and early-stage AD. Cognitive exercises may improve patients' reaction times and should be considered in routine treatment protocols.

Keywords: Computer-based cognitive training, reaction time, traumatic brain injury, early-stage Alzheimer's disease, applicability

INTRODUCTION

Alzheimer's disease (AD) is a progressive neurodegenerative disorder affecting all cognitive domains, especially memory (1). It is estimated that the number of Alzheimer's patients will be 115.4 million in 2050 in the world (2). In "Early-stage AD" which is the initial stage of AD, the functionality of patients is relatively preserved despite difficulties in more than one cognitive area, and they can live independently (3). It is already known that the effect of acetylcholinesterase inhibitors and memantine usage in the treatment is limited. For this reason, non-pharmacological methods have been applied to patients recently in addition to pharmacological treatment (4). Traumatic Brain Injury (TBI) is defined as the structural and physiological deterioration of the brain functions caused by an external force. After this deterioration, decreased level of consciousness or complete loss of consciousness, inability to remember events before or after the injury, mental status changes, neurological deficits, or intracranial lesions can be experienced (5).

It is a critical healthcare issue as it mostly affects young adults and causes advanced functional limitations in survivors (6). A multidisciplinary approach is recommended in the management of TBI. Cognitive interventions targeting memory, attention, executive, and visuospatial functions, therapies for regaining behavior, mood and insight, sleep therapy, and vestibular rehabilitation are very important in the rehabilitation process in addition to physical rehabilitation (for gait, balance and mobility) (7).

Cognitive training is considered to be effective both in reducing cognitive deficits in the AD process and the treatment of cognitive dysfunction in TBI patients (8, 9). Cognitive training is defined as systematic, functionally focused therapeutic activities based on the understanding and evaluation of the brain-behavioral deficiencies of patients (10). It is already known that Computer-Based Cognitive Training Programs (CBCT), whose difficulty level increases gradually according to patients' performance, are the most beneficial intervention in this field (11).

It was shown that the exercises in these programs can result in improvement in memory, executive functions, naming, attention, social cognition, and information processing speed skills in both diseases (12, 13). Also, the easy implementation of CBCT programs has an important advantage for patients and their caregivers and healthcare professionals who deal with these groups (14).

The purpose of the present study was to investigate the effects of the Computer-Based Cognitive Training Program on reaction times of patients with early-stage Alzheimer's disease and traumatic brain injury. It was also aimed to evaluate the applicability of this program for patients with various levels of cognitive dysfunction.

MATERIAL and METHODS

Patients

The data of patients who presented to the neurology clinic between January 2018 and December 2021 and who had at least 20 sessions of the CBCT program because of cognitive dysfunctions were evaluated retrospectively. The study included fourteen Alzheimer's patients who met the diagnostic criteria of "Possible AD" according to the latest diagnostic guideline (15). Seventeen TBI patients who had an open, closed, or penetrating head injury and therefore received physical rehabilitation treatment and whose cognitive deficits were detected after neuropsychological evaluation. Alzheimer's patients were in the mild dementia stage (CDR:1) according to the Clinical Dementia Rating Scale (CDR) (16). TBI patients were selected among mild/moderate patients who had lesions and brain damage that were detected in

brain imaging (17). Those who did not complete the CBCT Program, had insufficient data in their medical record, had severe systemic diseases that could affect cognitive functions, and were still receiving cancer treatment were excluded from the study. The age, gender, educational status, marital status, systemic diseases, family history for dementia, and disease duration (according to symptom onset) of the patients were recorded.

Ethics committee approval was obtained for the study and necessary consents were obtained from the relatives of the patients that their data could be used for scientific purposes. The study was conducted in line with the principles of the Declaration of Helsinki 2008.

NoroSOFT® Cognitive Training Program

NoroSOFT® Cognitive Training Program was applied to all participants in sitting positions. This program includes Turkish exercises prepared in line with Turkish culture and can be applied online on the web, which improves memory, attention, concentration, executive functions, visual-spatial perception, and conceptualization skills. The percentage of accuracy and reaction times of the answers given are determined by the scores in the five cognitive sub-domains mentioned above. As the total daily score (determined from the answers and reaction times) increases, the exercises become more difficult. A total of ten exercises, two from each of these five cognitive domains, were applied to the patients in each session, which lasted approximately 25-30 minutes (3 days a week, a total of 8 weeks). The patients' total scores, total accuracy percentages, and total levels were determined in these five areas at the end of the program.

Also, the reaction times of all patients in the first and last session of their performance in the CBCT program were recorded in seconds.

Statistical Analysis: The SPSS 21.0 (Statistical Package for Social Sciences, Chicago, IL, USA) was used for statistical analysis. Descriptive statistics were expressed as mean ± standard deviation for continuous and discrete numerical variables, and the number of cases and percentage (%) for the nominal variables. The comparison of data that were expressed as percentages was compared with the Fisher Freeman Halton Test and the Chi-Square Test, and the continuous variables were compared with the Mann-Whitney U-Test. $p < 0.05$ values were considered statistically significant.

RESULTS

In this study, the data of 31 patients [17 Traumatic Brain Injury (54.8%), 14 Early-Stage Alzheimer's disease (45.2%)] who completed the CBCT Program were analyzed. The mean age of Alzheimer's patients was 73.28 ± 4.89 years, and the mean age of TBI

patients was 30.94 ± 12.24 years. All AD patients were receiving Donepezil 10 mg/day for treatment. Those who had a diagnosis of TBI did not use any medical treatment for cognitive dysfunction. The demographic characteristics of the patients are summarized in Table 1.

The mean reaction time of TBI patients in the first session when they started the CBCT Program was 14.55±7.32 sec, and 13.43±6.90 sec for AD patients. The reaction time in the last session of the approximately eight-week program was 7.23±3.07 sec in those with TBI, and 9.48±3.55 sec in AD patients. The reaction times at the end of the program were significantly better in both groups than before (p<0.01, p<0.01).

The total exercise scores, accuracy percentages, and the total levels reached by the patients in the five sub-domains obtained at the end of the CBCT program are given in Table 2. Total memory scores were significantly better in patients with TBI than in patients with AD (1404.64±435.87 points, 932.47±503.06 points p=0.01, respectively) at the end of the program. It was also found that the reaction time in the last sessions of TBI patients was faster than AD, although not statistically significant (7.23±3.07 sec, 9.48±3.55 sec; p=0.06). No significant differences were detected between the two groups in terms of percentage of total accuracy, total level achieved, total attention and concentration, executive functions, visuospatial perception, and conceptualization scores.

There was no drop-out of the patients during the program. Also, no side effects were reported.

DISCUSSION

The results of the present study showed that the eight-week CBCT program improved the information processing speeds of both early-stage Alzheimer's patients and patients with Traumatic Brain Injury. However, the total memory scores of TBI's were found to be higher than those with AD at the end of the program. Also, it was stated in subjective feedback that this program was easily applicable and sustainable by the patients, and no negative effects were observed during the program.

Recently, in diseases such as TBI and AD causing cognitive damage, it is considered that cognitive training practices can reduce and/or improve the progression of cognitive deficits as well as medical treatments (8, 13). It is already known that especially CBCT programs are more effective than traditional paper-pencil methods and occupational therapy applications (11, 13). It was found that these programs stimulate residual cognitive skills in TBI patients resulting in improvement in many cognitive areas, especially memory and attention (18). Similarly, it was also speculated that rehabilitation of posttraumatic memory, attention, and executive functions may provide positive effects in improving symptoms (17, 19). Because of these positive effects, CBCT programs are recommended in the clinical management of patients with TBI (20). As in TBI, moderate positive effects of such exercises on cognition were demonstrated in early-stage AD as well (11).

Table 1. Demographic characteristics of the patients diagnosed with TBI and AD

	TBI	AD
Gender, Male, n (%)	10 (58.8)	12 (85.7)
Age, Years (Mean±SD)	30.94±12.24	73.28±4.89
Marital status, Married, n (%)	4 (23.5)	11 (78.6)
Presence of systemic disease, n (%)	1 (5.9)	12 (85.7)
Family history of dementia, n (%)	1 (5.9)	5 (35.7)
Education duration, years (Mean±SD)	10.88±3.10	7.78±2.75
Disease duration, years (Mean±SD)	2.11±2.06	1.53±0.84

TBI: Traumatic brain injury; AD: Alzheimer disease; SD: Standard deviation

Table 2. Scores of patients after the CBCT program and reaction times of the first and last session

	TBI	AD	p
Total accuracy percentage (Mean±SD)	77.17±7.10	75.28±6.83	0.45
Total level (Mean±SD)	4.88±2.86	6.21±1.88	0.14
Total memory score (Mean±SD)	1404.64±435.87	932.47±503.06	**0.01***
Total attention and concentration score (Mean±SD)	1285.05±916.66	1532.85±585.48	0.38
Total executive function score (Mean±SD)	788.64±507.22	761.21±325.80	0.28
Total visual-spatial perception score (Mean±SD)	904.41±632.19	1080.64±529.22	0.41
Total conceptualization score (Mean±SD)	520.05±324.18	639.21±283.51	0.29
First reaction time (Mean±SD)	14.55±7.32	13.43±6.90	0.66
Last reaction time (Mean±SD)	7.23±3.07	9.48±3.55	0.06

CBCT: Computer-based cognitive training; TBI: Traumatic brain injury; AD: Alzheimer's disease; SD: Standard deviation; *p value < 0.05

It was suggested that these practices may provide some positive effects in improving the learning and short-term memory performance of patients with mild cognitive impairment and/or dementia (21). In the present study, it was shown that cognitive function scores improved in TBI patients and early-stage AD patients after the CBCT program, in line with previous studies. Total memory scores of patients with TBI were better than those with AD at the end of the CBCT program. This may be because of the static lesions in TBI patients and the absence of a degenerative process. Also, the younger age of TBI patients and the lower incidence of comorbidities that may affect cognitive functions may explain this difference.

It was found in the present study that there was a significant improvement in the reaction time, in other words information processing speed, of the patients in both groups at the end of the program which was consistent with previous studies. In a randomized controlled study conducted with fifty early-stage AD patients, it was shown that a 15-week CBCT program increased the information processing speed of the treated patients when compared to the controls in each session lasting approximately one hour and applied twice a week (22). Similarly, a meta-analysis of 12 studies speculated that these exercises might be a valid complementary treatment method especially for age-related reaction times (12). The effects of CBCT programs on reaction times of TBI's are similar to those of AD. In a review conducted by Sigmundsdottir L. et al., it was argued that Computer-Based Cognitive Training has moderate to strong evidence in improving the reaction times of patients in TBI (23). In the present study, the reaction times of TBI patients were found to be better than those with AD at the end of the program, although no statistically significant differences were detected. Large-scale randomized studies are needed to demonstrate whether there is a difference in reaction times in these two diseases.

It was found that these programs are easily applicable and sustainable for patients who have degenerative and posttraumatic cognitive impairment (11, 24). The clinical usefulness of these ergonomically designed programs was confirmed by the increased performance of all patients in the functions investigated (25). The results of the present study were compatible with other studies. All of the patients completed the eight-week CBCT program successfully, and there was no drop-out. Also, with subjective feedback from the patients, it was learned that the motivation of the patients was high during the program and no side effects were observed.

Cognitive training creates changes in the structure of synapses and increases neurogenesis (26).

It is considered that cognitive exercises can improve cognition in both AD and TBI patients providing preliminary evidence for neuroplasticity (8, 27).

The present study had some limitations. Since it has a retrospective design, it was not possible to reach the neuropsychological evaluations of the patients before and after the program from the file data. Also, the number of patients analyzed in the study was relatively small. Therefore the benefit of moderate to severe TBI patients from this program could not be analyzed.

CONCLUSION

Computer-Based Cognitive Training programs are easily applicable and sustainable applications in traumatic brain injury and early-stage Alzheimer's patients. Cognitive exercises improve patients'reaction times and must be included in routine treatment protocols. Randomized controlled large-scale studies are required to more clearly demonstrate the cognitive and behavioral effects of such programs on people with both degenerative and posttraumatic cognitive impairment.

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