Dusunen Adam The Journal of Psychiatry and Neurological Sciences 2017;30:354-363
DOI: 10.5350/DAJPN2017300410

Case Series / Olgu Serisi

The Effects of Computer-Based Rehabilitation on the Cognitive Functions of Epilepsy Patients

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ABSTRACT

The effects of computer-based rehabilitation on the cognitive functions of epilepsy patients

Objective: The aim of this study was to examine the effects of computerized cognitive rehabilitation programs conducted with the purpose of slowing down cognitive losses and developing coping strategies in patients diagnosed with cryptogenic and symptomatic focal epilepsy, with participants' cognitive functions being evaluated through neuropsychological tests prior to and after rehabilitation.

Method: Of 32 patients who were receiving treatment at the Istanbul University, Cerrahpasa Faculty of Medicine Hospital, Department of Neurology Epilepsy Clinic, 9 patients who met the inclusion criteria underwent an 8-consecutive-week computer-assisted cognitive rehabilitation program conducted by a psychologist once a week. The effectiveness of the program was tested with a comprehensive neuropsychological assessment both before the rehabilitation program and 3 months after its completion.

Results: Test scores of patients before and after the rehabilitation were found as follows: Stroop-1 12.22±2.72; 11.55±4.36, Stroop-2 14.55±4.95; 15.55±9.20, Stroop-3 34.11±15.59; 26.44±12.25, Spatial Recall Test-1 14.22±5.99; 15.88±6.79, Spatial Recall Test-2 4.22±2.94; 6.88±2.93, Selective Reminding Test-1 55.88±11.95; 56.0±7.0, Selective Reminding Test-2 8.77±3.83; 8.77±2.72, Digit Symbol Substitution Test 38.33±19.31; 37.66±24.35, Lexical Verbal Fluency Test 25.77±11.3; 33.66±14.47, Semantic Verbal Fluency Test 15.77±4.52; 17.88±5.88. The pre- and post-rehabilitation scores of Stroop-3, Spatial Recall Test (SRT)-2 and Lexical Verbal Fluency tests were significantly different ($p<0.05$). The Beck Depression Inventory scores of patients were significantly reduced following the rehabilitation program ($p<0.05$).

Conclusion: An improvement in attention/vigilance, executive functions, information-processing, verbal fluency, and spatial memory were observed with cognitive rehabilitation; however, there was no improvement in verbal learning. The study showed that implementation of rehabilitation programs might assist in developing different cognitive function impairments witnessed in patients with epilepsy. There is need for more comprehensive research on this matter.

Keywords: Cognitive impairment, cognitive rehabilitation, epilepsy

ÖZET

Bilgisayar temelli rehabilitasyonun epilepsi hastalarının bilişsel işlevlerine etkileri

Amaç: Kriptojenik ve semptomatik fokal epilepsi tanısı almış olgularda, bilişsel kayıpların yavaşlatılması ve başa çıkma stratejilerinin geliştirilebilmesi için yürütülen bilişsel rehabilitasyon programlarının uygulanması ve rehabilitasyon öncesi ve sonrasında bilişsel işlevleri, nöropsikolojik testler aracılığıyla değerlendirilerek, uygulanan rehabilitasyon programının etkilerinin test edilmesi amaçlanmıştır.

Yöntem: İstanbul Üniversitesi Cerrahpaşa Tıp Fakültesi Hastanesi Nöroloji Anabilim Dalı Epilepsi Polikliniği'nde tedavi gören 32 hasta arasından, çalışma kriterlerine uygun olan 9 hastaya ardışık 8 hafta boyunca, haftada bir kez psikolog eşliğinde bilgisayar destekli bilişsel rehabilitasyon programı uygulanmıştır. Programın etkisi, rehabilitasyondan önce ve 3 ay sonra uygulanan nöropsikolojik değerlendirme puanlarının karşılaştırılmasıyla değerlendirilmiştir.

Bulgular: Yaş ortalaması 36.2±10.7 olan hastaların rehabilitasyon öncesi ve sonrası test skorları sırasıyla; Stroop-1 12.22±2.72; 11.55±4.36, Stroop-2 14.55±4.95; 15.55±9.20, Stroop-3 34.11±15.59; 26.44±12.25, Uzamsal Hatırlama Testi-1 14.22±5.99; 15.88±6.79, Uzamsal Hatırlama Testi-2 4.22±2.94; 6.88±2.93; Seçici Hatırlama Testi-1 55.88±11.95; 56.0±7.0, Seçici Hatırlama Testi-2 8.77±3.83; 8.77±2.72, Sayı Sembolleri Testi 38.33±19.31; 37.66±24.35, Leksikal Sözel Akıcılık 25.77±11.3; 33.66±14.47, Semantik Sözel Akıcılık 15.77±4.52; 17.88±5.88 olarak bulunmuştur. Yapılan analizler sonucunda, Stroop-3, Uzamsal Hatırlama Testi-2 ve Leksikal Sözel Akıcılık testlerinin bilişsel rehabilitasyon öncesi ve sonrası puanları arasında istatistiksel olarak anlamlı farklılık gözlenmiştir ($p<0.05$). Hastaların Beck Depresyon Envanteri'nden aldıkları puanlar da, rehabilitasyon programı sonrasında anlamlı olarak azalmıştır ($p<0.05$).

Sonuç: Bilişsel rehabilitasyon sonrası dikkati sürdürme, yürütücü işlevler, bilgi işleme hızı, sözel akıcılık ve görsel bellekte düzelme saptanmış, sözel öğrenme üzerinde değişiklik gözlenmemiştir. Bu çalışma bilişsel rehabilitasyon çalışmaları ile epilepsi hastalarında görülen farklı bilişsel işlev bozulmalarında bir gelişme sağlanabileceğini göstermektedir. Bu konu ile ilgili daha kapsamlı çalışmalara ihtiyaç vardır.

Anahtar kelimeler: Bilişsel bozukluk, bilişsel rehabilitasyon, epilepsi

How to cite this article: Icellioglu S, Bingol A, Kurt E, Yeni SN. The effects of computer-based rehabilitation on the cognitive functions of epilepsy patients. Dusunen Adam The Journal of Psychiatry and Neurological Sciences 2017;30:354-363. https://doi.org/10.5350/DAJPN2017300410

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Date of receipt / Geliş tarihi:
July 5, 2017 / 5 Temmuz 2017

Date of the first revision letter / İlk düzeltme öneri tarihi:
July 28, 2017 / 28 Temmuz 2017

Date of acceptance / Kabul tarihi:
August 8, 2017 / 8 Ağustos 2017

INTRODUCTION

Epilepsy is a neurological illness that is characterized by epileptic seizures. These seizures, which are triggered by abnormal paroxismal electrical activities of neurons, can spread into all other regions of the brain. They occur repeatedly and for an extended period of time and may negatively affect the patients' behavior along with the cognitive functions of their brain (1-4).

The level of impairment in the cognitive functions of epilepsy patients depends on additional factors such as the age at onset of epilepsy, the type and frequency of seizures, the epileptogenic zone, the use of anti-epileptic medication, and the application of surgical interventions (5,6). Cognitive impairments occur most frequently in the form of a slowing down in attention, intellect, linguistic skills, visual-spatial skills, problem-solving, verbal and non-verbal memory performance, and a slowing down in motor reactions (7).

The most advanced stages of cognitive decline are witnessed among epilepsy patients with an early onset of seizures, generalized tonic-clonic seizures, and long years of anti-epileptic drug usage (7). In many idiopathic epilepsy cases, cognitive functions are either slightly affected or remain at a normal level. However, in epilepsy patients who suffer from cryptogenic (no obvious cause) and symptomatic seizures, there is focal damage in parts of the cortex with an impairment in the related cognitive functions (2,4,5,8).

The effects of various cognitive rehabilitation programs on these cognitive impairments are being researched. In these studies, a special emphasis is placed on determining the goal of the rehabilitation program based on the cognitive characteristics of the patients, in order to develop a rehabilitation program that is tailored to meet the individual needs of the patient (9). Because of the pervasive existence of memory and attention impairment in patients diagnosed with focal symptomatic epilepsy, rehabilitation efforts have focused specifically on developing these functions. There are two basic approaches used in memory rehabilitation. While the first of these aims to develop the impaired functions through exercise, the second approach is a compensatory one which is based on helping the patients deal with the problems they face in daily life that stem from their memory problems (10). However, the findings of research on the effects of rehabilitation on epilepsy patients are contradictory (11,12). While the results pertaining to attention performance are more encouraging, the results were particularly found to be much more favorable when used together with compensatory strategies (13).

The goal of this study is to examine the effects of short-term computerized cognitive rehabilitation programs on cognitive functions in epilepsy patients. Patients were included in the study following a neuropsychological assessment administered at the beginning of the program. Following the completion of the cognitive rehabilitation program, patients were administered another neurological assessment, utilizing the same tests. The effects of the computerized cognitive rehabilitation program were evaluated based on the difference between the first and second neuropsychological test results.

METHOD

A total of 32 patients receiving treatment for the diagnosis of symptomatic and cryptogenic (no obvious cause) epilepsy at the Epilepsy Clinic in the Department of Neurology of the Hospital of Istanbul University's Cerrahpasa Faculty of Medicine were administered neuropsychological tests as well as the Beck Depression Inventory (BDI) – on account of the fact that epilepsy patients frequently exhibit depressive symptoms alongside cognitive impairment. These tests and the BDI were administered after receiving participants' voluntary consent. Patients suffering from cognitive impairment due to cognitive deficiency or for reasons not pertaining to epilepsy and those who were found uneducated, diagnosed with addiction, psychosis, or severe personality disorder were not included in the study. Patients residing outside of Istanbul were also not included due to the decreased likelihood of their consistent participation in the rehabilitation sessions. Of the patients, 15 were

women and 17 men. The mean age was 32.5 (±12.5) years. Their age range was 14-63 years.

Nine patients who wished to participate in the rehabilitation program following the first neuropsychological assessment were included in the cognitive rehabilitation program. Subjectively, three of the patients complained of forgetfulness and attention deficit while five complained only of forgetfulness and one patient had no cognitive complaint. Of the participants in the study, 6 of the 9 patients had symptomatic epilepsy while 3 had cryptogenic (cause unknown) epilepsy. Seven of the patients were women and 2 were men. The mean age was 36.2 (±10.7), while the age range was 25-60. Four of the patients were primary school graduates and 5 high school graduates. At the time when the study was carried out, the patients' illness period varied between 18 months and 30 years and the mean was 13.5 (±10.3) years. While 5 of the patients did not experience any seizures during the rehabilitation period, 4 suffered from seizures recurring in various intervals. All of the patients were using anti-epileptic medication, and the average number of drugs being taken was 2.2 (1-4). When examining the MR findings of the patients, 1 patient was observed to have right superior temporal dysplasia; 1 patient bilateral hippocampal atrophy; 2 patients had right mesial temporal sclerosis (MTS); 1 patient had left MTS and 1 patient bilateral occipital encephalomalacia. The remaining 3 patients' MR findings were normal. In 7 patients, the epileptic zone was determined to be their temporal lobe, while it was found to be the occipital lobe in 1 patient. The remaining patient's epileptogenic area could not be determined.

Three months after the completion of their cognitive rehabilitation program, the patients were once again evaluated with the same neuropsychological tests and BDI.

Measures

Attention/vigilance, information-processing, working memory, verbal fluency, as well as verbal and non-verbal memory functions were assessed with the tests indicated below.

Stroop Test: The Stroop Test (14,15) is a neuropsychological test measuring the skill of parallel processing of what is focused on and distracting stimuli; as well as the information-processing speed and the ability to ignore distracting stimuli (16). In this study, reading (section 1) the word that is written on a card carrying the names of colors which are printed in black on a card (card 1), reading (section 2) a card carrying the names of colors printed in various colors (card 2) and saying (section 3) the names of colors printed in various colors (card 2) were evaluated. The time it took to pronounce the name of a color written in a differing color was longer than the time it took to read the colors. The Stroop Test measures the skill of suppressing the distractive effect of this color-word stimulus.

Selective Reminding Test: The Selective Reminding Test (SRT) measures the verbal memory processes. The test contains 12 words that are not semantically or lexically related to one another. In the first trial, all of the 12 words are read and the participants are asked to recall as many words as they can. In the remaining five trials, the participant is read the words which they were unable to recall in their previous trial. Following a 20-25 minute period of delay, the participants are asked to recall as many words as they can. The total number of words they remember in their first six trials form their total learning score (SRT-1), while the number of words they recall after the 20-25 minute delay forms their delayed free recall score (SRT-2) (17). Normative data from a Turkish healthy population was obtained in a study by Bingöl et al. (18).

10/36 Spatial Recall Test: The 10/36 Spatial Recall Test (SPART) is a measure of visuospatial memory. The participant is asked to memorize the location of 10 circular tokens placed on the squares of a 6 by 6 checkerboard in three learning sessions of 10 seconds each. Following a 20-25 minute delay period, they are asked to recall the location of the tokens (19). The total score obtained from three trials (SPART-1) and the delayed recalling score (SPART-2) were

included in the analysis. Normative data from a Turkish healthy population was obtained in a study by Bingöl et al. (18).

The Digit Symbol Substitution Test: The Digit Symbol Substitution Test (DSST) is a test that measures visual/spatial processing speed and working memory. There are nine symbols on the top of a page, each paired with a number. At the bottom of the page there are numbers written in a mixed order, and the participant is asked to quickly draw the symbol paired with the number in the space provided below the number. The number of symbols drawn correctly by the participant within 90 seconds is calculated (20). Normative data from a Turkish healthy population was obtained in a study by Bingöl et al. (18).

Verbal Fluency Test: In the Verbal Fluency Test (VFT), the participant is asked to generate words that are not proper nouns within a period of 60 seconds. In the letter fluency test, participants are asked to produce words that are non-proper nouns that begin with the letters K, A, and S respectively, within 60 seconds. In the semantic fluency test, the participants are asked to produce words in the category of animals (20). Lexical fluency (LF), which was assessed with the letters K, A, and S, and semantic fluency (SF), which was assessed with the animal category, were evaluated separately. Normative data from a Turkish healthy population was obtained in a study by Bingöl et al. (18).

Beck Depression Iventory (BDI): Patients' depression scores were assessed using the BDI. The BDI is a four-point Likert-type scale consisting of 21 statements. When evaluating patients' statements, they are asked to respond based on their behavior over the past week (20). Validity and reliability study for Turkish version was conducted by Hisli et al. (22).

Computerized Cognitive Rehabilitation Program

The cognitive rehabilitation program comprises the consistent repetition of computerized exercises geared towards attention, memory, and executive functions that are conducted in regular intervals. Each of the nine patients who participated in the rehabilitation program were administered a weekly exercise that lasted 45 minutes over a period of eight weeks under the supervision of a psychologist in a hospital setting. Bellexfit was used as a rehabilitation program. This program features support software that provides cognitive exercises to slow down neurological and endocrine disorders that are following a degenerative and chronic trajectory in particular, and, if possible, contribute to their regeneration. Regular exercises tailored for specific cognitive areas were chosen based on the individual cognitive damage in the patients. Patients were administered seven different exercises contained in the "Memory and Attention" module, geared towards attention, memory and executive functions (visual attention training, visual motor memory, visual design recalling, letter recalling, recalling numbers, concentration, attention, perception, and differentiation). Every exercise contained levels of increasing difficulty. Appropriate beginners levels were determined for the patients based on their cognitive status, with patients moving on to the next level only upon completion of a minimum performance level of 80%. The basic aim of the program was to regain the impaired cognitive functions by way of exercise. Figure 1 contains a sample screen shot of the motor memory application that was used in the program.

Statistical Analysis

In this study, the statistical analysis was conducted using version 23 of SPSS (Statistical Package for Social Sciences, Chicago, US). The data was analyzed according to the number of variables to be examined and number of participants, using definitive statistical methods, the Wilcoxon Signed-Rank test, the Spearman correlation test, and the Mann-Whitney U Test. The significance of the findings was evaluated at the level of $p<0.05$.

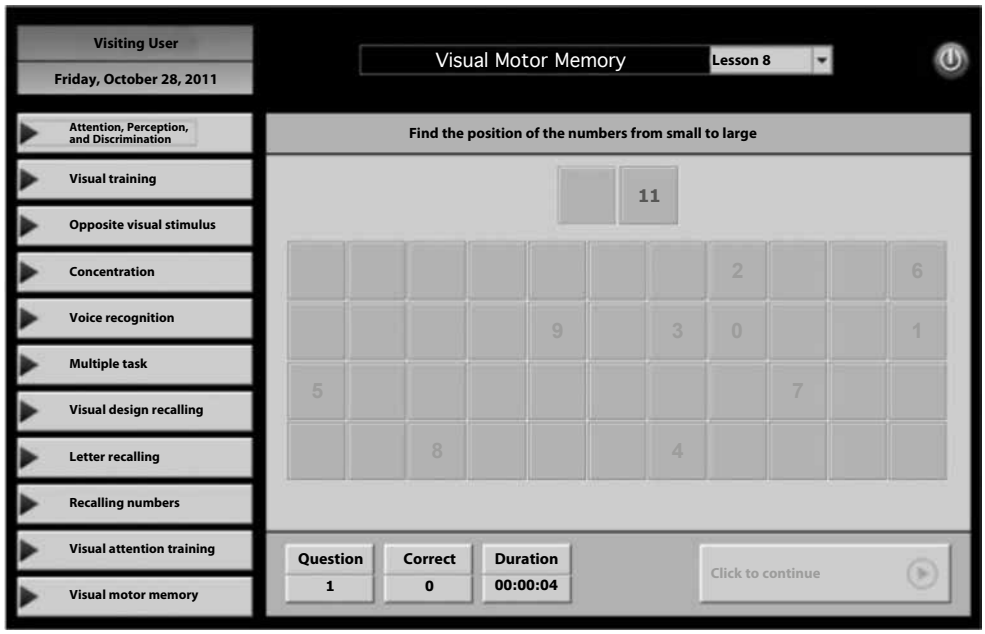

Figure 1: Screenshot of Neurosoft visual-motor memory training

RESULTS

Nine patients who met the inclusion criteria of the study were examined during the periods of the study. As indicated in the previous sections, the participants' ages ranged between 25 and 60 with their mean age being 36.2 years [standard deviation (SD) ±10.7 years]. While 77.8% of the participants were women (n=7), 22.2% (n=2) were men. The illness duration of the participants ranged from 18-30 months with a mean value (±SD) of 13.5±10.3 years.

Of the participants included in the study, 55.6% (n=5) were primary school graduates and 44.4% (n=4) were high school graduates. Their BDI scores ranged between 4 and 37, with a mean (±SD) of 22.33±10.95.

There were significant differences found following the administration of the Wilcoxon signed-rank test analysis between pre-test and post-test BDI scores ($z=2.55$; $p<0.05$); between the Stroop Test-section 3 first and second administration completion periods ($z=-2.49$; $p<0.05$); between SPART-2 first and secondary application score results ($z=1.98$; $p<0.05$), and lastly between the pre-rehabilitation and post-rehabilitation lexical fluency total scores ($z=-2.19$; $p<0.05$).

The relationship between the test scores which were found to differ in their application in pre- and post-cognitive rehabilitation were examined with the Spearman correlation test; the Stroop Test section 3 scores were found to have a significant positive ($p<0.05$, $r=0.57$) correlation with age; while the Semantic Verbal Fluency Test-Letter K pre-cognitive rehabilitation test scores were found to have a significant negative ($p<0.05$, $r=-0.057$) correlation with age.

The difference in the test scores of the primary and high school graduate participants based on their level of education was compared using the Mann-Whitney U Test with no difference being found in the performance between groups.

Following analysis, the relationships between test scores that were found to have significant differences pre- and post-rehabilitation (SPART-2, LF, and Stroop-3) and duration of illness and number of medications taken were examined. The relationship between SPART-2 scores pre- and post-rehabilitation and the number of medications used and illness duration were examined using the Pearson correlation analysis, and no significant relationship was found. While no relationship was

Table 1: Pre- and post-rehabilitation mean scores of administered cognitive tests

	First test results Pre-rehabilitation				Second test results Third month post-rehabilitation					
	Mean	SD	Lowest	Highest	Mean	SD	Lowest	Highest	z	p
Stroop-1	12.22	2.72	8	17	11.55	4.36	8	22	-0.92	0.36
Stroop-2	14.55	4.95	9	24	15.55	9.20	8	38	-0.07	0.94
Stroop- 3	34.11	15.59	18	67	26.44	12.25	13	56	-2.49	0.01*
SPART-1	14.22	5.99	5	26	15.88	6.79	6	26	-1.02	0.31
SPART-2	4.22	2.94	0	8	6.88	2.93	2	10	-1.98	0.04*
SRT-1	55.88	11.95	37	70	56.0	7.00	44	64	-1.49	0.13
SRT-2	8.77	3.83	0	12	8.77	2.72	3	12	-0.87	0.38
DSST	38.33	19.31	15	68	37.66	24.35	0	68	-0.12	0.91
LF	25.77	11.30	0	42	33.66	14.47	3	58	-2.19	0.02*
SF	15.77	4.52	8	20	17.88	5.88	8	25	-1.81	0.07

*p<0.05. SD: Standard Deviation; SPART-1: Spatial Recall Test trials total score, SPART-2: Spatial Recall Test delayed recall,
SRT-1: Selective Reminding Test Total Learning, SRT-2: Selective Reminding Test delayed recall, DSST: Digital Symbol Substitution Test, LF: Lexical Fluency, SF: Semantic Fluency

found between pre- and post-rehabilitation LF scores with the number of medications used, a significant negative relationship was found with the length of illness (for pre-rehabilitation r=-0.74, p<0.05; and for post-rehabilitation r=-0.711, p<0.05). The period of illness was investigated in order to determine the difference between pre- and post-rehabilitation LF scores, while the ANOVA was applied in order to test the one-way repeated measures, with the period of illness being added to the model as a co-variant. The interplay between period of illness and test scores was found to be insignificant ($F[1,7]=0.81$, $p=0.39$, $\eta^2=0.104$). Lastly, the relationship between the period of illness and the number of medications used and the pre- and post-rehabilitation Stroop-3 scores were examined by Pearson correlation analysis, and while there was no significant relationship found with the number of medications used, there was a significant positive relationship found for both pre- and post-rehabilitation Stroop-3 scores and the period of illness (r=0.79, p=0.01; r=0.83, p=0.005 respectively). Similar to the previous analysis, the period of illness was examined and the one way repeated ANOVA analysis found that there was interplay between the period of illness and the pre-rehabilitation and post-rehabilitation score change ($F[1,7]=0.76$, $p=0.41$, $\eta^2= 0.09$).

In the end, an improvement through cognitive rehabilitation was seen in executive functions, information-processing speed, spatial recalling, and verbal fluency functions; however, no change was observed in verbal learning skills pre- and post-cognitive rehabilitation (Table 1).

DISCUSSION

The epileptic seizures and treatments pertaining to epilepsy affect patients' daily social life, psychiatric state, and cognitive functions. Individuals who have been diagnosed with epilepsy exhibit a pervasive impairment in their neuropsychological functions as compared to healthy individuals; the reasons for the degree of this impairment, in addition to its distribution, are subject to change based on multiple factors (1). Thus, studies conducted to improve the quality of life of every chronically ill patient as well as epilepsy patients in relation to said functions has been gaining importance as of late. One of the factors affecting epilepsy patients is anti-epileptic medicine. There are studies that reveal the negative effect these drugs have on cognitive functions (23,24). There are various treatment methods to solve cognitive impairments caused by factors such as characteristic seizures or drug treatments. Vagus nerve stimulant, cholinergic applications, anti-depressants, as well as anxiety medication and stimulants are some of the treatment methods whose effects on patients have been experimentally tested, yet their effectiveness still

continues to be a matter of debate (25).

In addition to the treatments listed here, cognitive rehabilitation programs that have been implemented more recently also aim to increase the quality of patients' lives and decrease cognitive impairment. Cognitive rehabilitation programs are shaped with two basic approaches in mind. The first approach aims to give the patient awareness in the face of cognitive impairment and regain these skills through repeated cognitive practices. The other approach includes compensatory methods which the patients can use directly in their everyday life (26). In a study that examines which of these two approaches is more effective clinically, it was found that both methods lead to progress in cognitive functions; however, compensatory applications were more effective overall (13). In another study where, in addition to neuropsychological group therapy, patients were administered 4-5 sessions of cognitive exercises on average in one week, it was found that rehabilitation had a positive effect on their remaining cognitive memory, in particular among patients who had undergone surgery in their right hemisphere (11). In other studies, there were subjective and objective improvements measured in their memory functions (27,28). In our study, too, the aim was for epilepsy patients who had subjective cognitive complaints to participate in a computerized rehabilitation program, demonstrating the effects of this program on cognitive performance.

Two of the 9 patients in our study were men. One of the reasons for this limitation – an imbalance between men and women – was the fact that this study required consistent attendance, and because the male patients, too, were from the working class, they were unable to participate in the program regularly. The ages of the patients ranged from 25-60 years, with the mean age being 36.2±10.7 years. No relationship was found between increasing test scores after rehabilitation and age. Similarly, no relationship was determined between participants who were high school and primary school graduates and their pre- and post-rehabilitation neuropsychological test scores.

Epilepsy patients frequently experience depression and anxiety symptoms and cognitive inhibitions accompany depressive symptoms (9). In our work, in addition to the neuropsychological test scores of patients, their pre- and post-rehabilitation BDI scores were compared with a decrease in their depression following rehabilitation being observed. When the increase of test scores pertaining to the evaluation of attention is taken into consideration, we can say that rehabilitation produced positive effects on mood and cognitive functions.

In epilepsy patients, the response inhibition, which has the power of suppressing distracting stimuli, is reduced when compared to healthy individuals (29). When we look at the neuropsychological test scores, there is a significant decrease in the Section 3 periods, which aims to evaluate the opposing force against the damaging effect interference of the Stroop test. In other words, patients were able to complete this task in a shorter period of time following rehabilitation. Secondly, there was an increase found in the lexical verbal fluency scores of patients in comparison to pre-rehabilitation. VF is evaluated in two ways: semantic and lexical. While semantic verbal fluency is more related to the temporal lobe, lexical verbal fluency is more related to the frontal lobe (30). The positive change in the Stroop-3 scores, a test that evaluates the lexical verbal fluency and the response inhibition, could be an indicator that the computerized rehabilitation program has positive effects on attention and concentration functions. Thirdly, while no significant difference was found in the verbal memory tests prior to and after rehabilitation, there was a significant difference in the delayed recalling scores of the visual memory test. While the total learning score of the test is related to short-term visual memory, in other words pertaining to attention, the SPART-2, which is calculated as the second score in the test, evaluated the process of retrieving the visual information from the memory. When we look at patients' SPART-1 scores, which evaluate the pre-rehabilitation visual memory learning scores, and their SPART-2 scores, which are their delayed memory scores, we see that they can remember only quite a low number of answers in their task from among the

answers they gave from their instant memory. However, despite the small number of items recalled following rehabilitation kept in the delayed memory task, there is still a statistically significant increase observed. When looking at the scores of the patients prior to and post-rehabilitation program on a per-patient basis, we see that of the two patients' SPART-2 scores, which are their visual memory delayed recalling scores, one supports the right MTS findings, while the other supports the presence of a bilateral occipital encephalomalatic area, and their scores are quite high when compared with other patients. While both patients' verbal memory scores, which were measured with the SRT, were above normal as well, they had a deficient visual memory capacity, which is consistent with their pathology. Thus it is believed that the computerized rehabilitation program is particularly positively effective on impaired memory performance. Furthermore, when we look at the neuropsychological test scores of the two patients who did not suffer from seizures and whose periods of illness were shorter than those of their counterparts, we see that despite their subjective slight memory complaints, their pre-rehabilitation test scores were notably higher than in the other patients, and therefore, their post rehabilitation scores could not increase much due to the ceiling effect. When the patients' clinical characteristics are taken into consideration, it can be said that they have a performance impairment disorder which is at a level that does not reflect in standardized neuropsychological evaluations. On the other hand, when the number of drugs they take and the duration of their suffering from epilepsy is taken into account, we see that only the length of illness is related to their test performances and that this relation affects performance negatively as expected. However, as demonstrated in the results section of the study, the epilepsy period has not been found to have any effect on the effectiveness of the rehabilitation program. Patients, independently of their period of epilepsy, were able to increase their test scores in the SPART-2, Stroop-3 and VF tests. This finding demonstrates the importance of personalized computerized rehabilitation which begins at an appropriate level for each patient after determining their cognitive performance level.

The positive aspect of this study can be seen in its provision of preliminary findings regarding the possible effectiveness of computerized cognitive rehabilitation programs on epilepsy patients in particular. In addition to this type of programs, the implementation of compensatory practices will contribute positively to the patients' quality of life and their mood. Furthermore, this study is the first of its kind in its use of the Neurosoft software. In a review featuring 18 different studies on the topic, it is noted that the findings are not consistent; the methods of the studies are inadequate and patients' clinical characteristics were overlooked; therefore, there is a need for more studies in this field (31).

In our study, the tests were administered in the alternative forms method in their first and second applications in order to discriminate against the learning effect of neuropsychological tests. The most important limitations of this study are the lack of a control group, the short duration of the implementation period, and the small number of cases. The findings of this study should only be interpreted at preliminary results and should not be seen as decisive for clinical practice.

Despite its restrictions, this study is among the few cognitive rehabilitation studies conducted with epilepsy patients and thus has its significance. When the progressive trajectory of epilepsy is taken into consideration, it is not expected that progress would be made in the cognitive functions of patients in such a short period of time without the administration of any kind of rehabilitation program. However, the studies in the present literature – including longitudinal studies – were unable to find an improvement in the neuropsychological test scores of patients over time, with some patients even showing deteriorating performance (32,36). In a case study that examines the effects of computerized rehabilitation on cognitive functions in epilepsy, there was an increase in all neuropsychological test performances following a six-week program (37). Despite the absence of a control group in this study as well, the increase in the indicated

test scores of patients following an eight-week rehabilitation program can be interpreted as a positive effects stemming from the computerized rehabilitation program.

In summary, it is believed that computer-based rehabilitation programs have an improving effect on the cognitive impairments which negatively affect the quality of life of epilepsy patients. Thus, administering this method to different clinical groups, in addition to epilepsy patients, with large sample sizes over long time periods, is an approach that should be promoted.

Contributions category	Authors name
Development of study idea	A.B., S.N.Y., E.K.
Methodological design of the study	S.I., A.B.
Data acquisition and process	E.K., A.B., S.N.Y.
Data analysis and interpretation	S.I.
Literature review	S.I., A.B., E.K.
Manuscript writing	S.I., S.N.Y.
Manuscript review and revisation	S.N.Y., S.I.

Conflict of Interest: Authors declared no conflict of interest.

Financial Disclosure: Authors declared no financial support.

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