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Research Article

The Use of Computer Programs and their Effectiveness in the Rehabilitation of Executive Functions in Acquired Brain Damage. Review Article

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Abstract

Given the increase in the offer of computerized programs for the neuropsychological rehabilitation of patients with acquired brain damage, it is important to know their efficacy and the advantages of their application on different processes. This article reviews the use of these programs in the neuropsychological rehabilitation of executive functions in patients with acquired brain damage.

The search was carried out in sources such as PUBMED, internet searches and some lists of bibliographic references. Controlled, randomized articles were reviewed, and due to the characteristics of the topic, quasi-experimental studies and a case study, adults, were also included, excluding only articles that included adults patients with acquired brain damage and who had executive function failure without specify one in particular and that they have received cognitive rehabilitation through computer programs. The results reflect weaknesses in the matching of the control groups, the size of their samples, and in the use of instruments for measuring executive functions to objectify efficacy. In general, the programs reviewed do not prove to be more effective than those of traditional pencil and paper interventions.

Keywords: *Neuropsychological Rehabilitation; Executive Functions; Acquired Brain Damage; Computer*

Introduction

Head trauma is one of the leading causes of death in people between 15 and 45 years of age [1] without however, this condition also occurs in other age groups such as childhood and the elderly.

Traumatic brain injury (TBI) is an alteration in the brain caused by the impact of an external agent against the skull in which the damage can be focal or distributed in various parts of the brain and the impact can cause an open or closed injury [2].

In general, people who survive skull trauma have multiple sequelae ranging from physical to cognitive and that together, affect their functionality and quality of life.

According to the severity of the trauma, individuals with a history of moderate to severe TBI are those who suffer the most physical, emotional and/or cognitive dysfunction measure, being able to observe combinations of these three aspects [3] the above regardless of the type of mechanism that caused the damage, as seen in the bullet impacts [4] or blows with large objects [5].

TBI directly or indirectly causes lesions in the parenchyma, the temporal and frontal areas being the most affected [6]. When the frontal lobes are damaged, alterations in executive functions are produced, which arise in these areas of the brain, causing deficits in planning [7] attention [8] memory of work [9], self-control [10] initiation and maintenance of goal-directed behavior [11] among many others.

Neuropsychological rehabilitation programs for executive functions in these patients have been shown to be effective, however there has been some controversy about whether computerized rehabilitation programs have the same effectiveness and even greater than those traditional pencil and paper programs.

On the other hand, the rehabilitation methodology in the studies carried out is sometimes unclear [12] so that the results cannot be generalized to the populations of interest.

Method

The search was carried out through databases such as PUBMED, as well as on websites and in the lists of bibliographic references of a systematic review that had titles with the topic of interest. The following keywords or sets of words were used with Boolean search engines in google or academic google: "executive function intervention" AND "traumatic brain injury in adults;" "Cognitive training" "brain injury;" "Acquired brain injury" and "lumosity;" "Acquired brain injury" AND "aid assistant;" "Computer program" AND "rehabilitation memory." There was no rigor in the type of study design since the main interest was to find studies that had neuropsychological intervention of executive functions through the computer or computerized method, however, we tried to collect Randomized controlled studies where possible.

Quasi-experimental studies, one case study, and clinical trials were also included. In the criteria for inclusion of the study sample, the following were considered: patients with moderate to severe head injury or acquired brain damage over 18 years of age with impaired executive functioning or in at least one function related to them, such as working memory and publications in English (See figure 1).

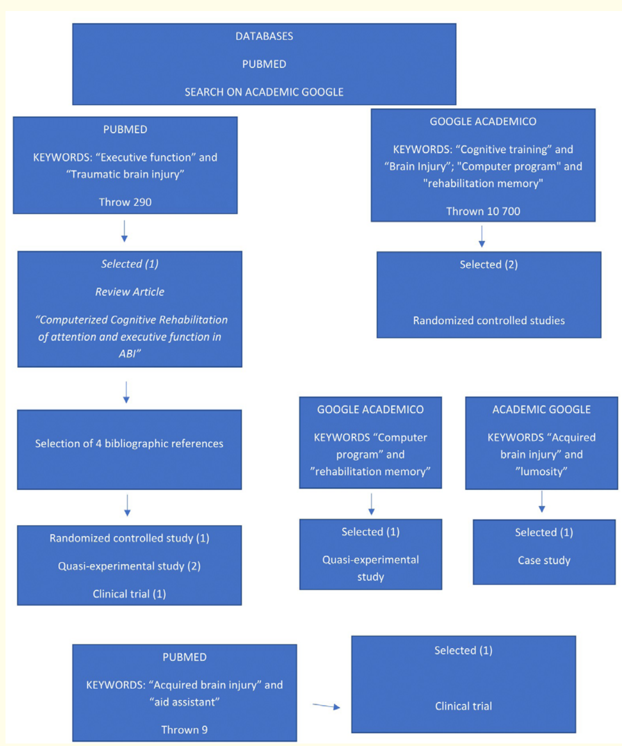

Figure 1: *Search process.*

Three articles were excluded due to the following reasons:

- One study used the MMSE as a diagnostic scale as well as the Wechsler Scale Memory, the results of the first instrument were shown in a graph where significant posttest scores were observed in functions such as information, mental control, digit span, associative learning, logical and visual memory without however the Results of the Wechsler scale that for the purposes of this review represent greater specificity of the areas of interest in executive functioning were not shown in score so that the performance of the patients could be analyzed later to the intervention with the computer program.
- A review article analyzed the effectiveness of neuropsychological rehabilitation programs for executive functions in people with brain damage However, the programs included in the review were not computerized.
- A third investigation was not included despite containing the variables of interest, however it was a preliminary study.

Results and Discussion

A total of 9 articles were included, of which 3 had a randomized controlled design, 2 clinical trials, 3 studies with a quasi-experimental design and 1 study of cases. The randomized controlled studies included patients with head trauma, the same situation occurred with the quasi-experimental ones, the case-control study included two people with skull trauma and one patient with a malformation cerebral. The clinical trials reviewed included patients with acquired brain damage, not precisely head trauma.

Patient characteristics

In total, the sample of patients that were studied in the articles Included in this review was 300 subjects, with a minimum of 18 years and a maximum of 75 years, with a high level of education in the majority, however, with a significant decrease in executive functioning, working memory, attention and decrease in quality of life, all of the above, after brain damage.

Characteristics of the interventions and rehabilitated processes

Those studies in which their intervention was based on a computerized program or given through a computer or electronic device were included. All the programs mentioned in the articles were related with cognitive stimulation exercises, some developed by companies that are experts in information technology and others by experts in the area of mental health. The studies reviewed here focused on the intervention of functions such as verbal and visual working memory, long-term memory, prospective memory, processing speed, executive functioning and in some other aspects were included such as functionality in daily life and at work, as well as depression and anxiety. See table 1.

Author(s)	Year	Type of study	n	Average age	Intervened functions	Type of intervention	Results
Twamley, EW., *et al*.	2014	Controlled randomized study	34	30 years old	Attention, speed of processing, memory of work, learning and memory Functioning executive (cognitive flexibility)	Program: cogSMART plus employment support program (experimental group) Employment support (control group)	Improvement in prospective memory over a period of 24 hrs There was no significant difference in the rest of cognitive functions between both groups
Jak AJ., *et al*.	2018	Controlled randomized study	51	35 years old	Speed of processing Learning and memory Divided attention Inhibition Flexibility	Program: cogSMART and CPT (experimental group) CPT (control group)	Improvement in the experimental group above the control in the speed processing Attention Working memory Learning and memory (immediate and delayed recall) Problem solving Cognitive flexibility and inhibition

Äkerlund, E., *et al.*	2013	Controlled randomized study	47	51 years old	Attention Working mejor	Program: COGMED QM plus traditional rehabilitation (experimental group). Traditional rehabilitation (control group)	Improvement in both groups in attention and working memory without significant differences
Chen SH., *et al.*	1996	Quasi-experimental Study	20	30 years old 6 months	Attention, resolution of memory problems visuo-spatial ability.	Program: Computer assisted Cognitive rehabilitation (CACR) (Control group and experimental received the program, varying the amount of hours received)	No significant differences were found between the groups ($p > 0.05$). Nor were significant differences found in the scores of the tests before and after treatment.
Ruff R., *et al.*	1994	Quasi-experimental Study	15	27 years old	Attention Memory	Program: THINKable One group received training first attention and later {{1}} from memory. The second group did it the other way around, both covered 20 hours of training.	The experimental subjects and controls improved in attention although without significant gains, in the same way improvements were observed in verbal and spatial memory in working memory but not in the delayed delay.
Sing Fai Tam y Wai Kwong Man	2004	Quasi-experimental Study	26	40 years old	Memory	Program: Computer assisted memory retraining (CAMR) Experimental group received memory training with the program in 4 different modalities per subgroup; the control group received memory intervention but without specific methodology	Of the 4 subgroups, only the training by visual presentation was the one that presented the greatest increase in performance percentage in the memory test. However, no significant improvement was obtained once the training was completed. The improvements observed were clinical [18].

Lundqvist A., *et al.*	2010	Clinical trial	21	43 years old	Verbal and visual working memory	Program: QM (Remembrance) Two randomly distributed groups in whom toasted the treatment with marked differences in the time interval for the application of the program in experimental and control group	Significant difference at 4 weeks after training but not 20 weeks after it.
De Joode EA., *et al.*	2013	Clinical trial	34	42 years old	Report Planning and organization, Attention	Program: (Planning and execution assistant and trainer) PEAT (Experimental group received training with a computerized program); (control group intervention with pencil and paper exercises)	Significant improvement in visual and verbal memory in delayed recall in the experimental group, although there was no significant difference with the control group in both measurements.
Connor, B. Shaw, C.	2014	Case study	3	Over 18 years	Attention and memory	Program: Lumosity Use of the computerized intervention during 24 sessions Pretest and posttest assessment	Modest improvement in 2 of 3 participants on objective outcome measures when examining memory and attention.

Table 1: *Descriptive table of the studies included in the review.*
**: CPT (Cognitive Processing Therapy).*

Randomized controlled studies

In San Diego, California, a study was conducted with war veteran patients to assess the effectiveness of the cogSMART program in these subjects who were unemployed and intending to return to work. According to its acronym in English, cogSMART (Cognitive Symptom Management AND rehabilitation therapy) is designed to be practical and easy to manipulate by the patient in order for the patient to generalize the skills to the real life. For this study, subjects who presented cognitive failures in at least one neuropsychological domain were chosen, which could be related to attention, processing speed, working memory, learning and memory. as well as executive functioning as measured by standardized neuropsychological tests. Participating study subjects were selected on based on their history of mild to moderate TBI and no history of substance use. A total of 34 patients were included as an experimental group who did not differ with the controls in age, education, sex, race, ethnicity, premorbid intelligence quotient (IQ), duration of loss of consciousness during your most severe skull trauma, or the sum of the duration of loss of consciousness following four head trauma, as well as symptoms related to depression, post-traumatic stress level, severity of head injury and time elapsed after the trauma [13].

To carry out this research, the experimental group was supported by a specialist in the {1} I used more treatment with cogSMART so that the pair were trained their cognitive skills and with it their application in the job in which they were candidates; while the control group was only provided professional support in the job to monitor performance. The experimental group received care 1 hour 1 time a week with cogSMART plus 2 visits weekly by the care professional and the other group only received 2 weekly visits in the use to control non-therapeutic factors provided in the computerized program [13].

Twelve weeks after the intervention, significant improvements and differences were achieved in the experimental group in prospective 24-hour time-lapse memory as well as in the Neurobehavioral Symptom Inventory (NSI) inventory that assesses Neuropsychiatric symptoms in war veterans. There were no significant differences in the other neuropsychological functions, severity of behavioral symptoms, quality of life and job performance. However, there was a small to medium effect size improvement in psychiatric symptoms and 5 participants who did not have cogSMART training improved in competitiveness compared to 8 who did. Similarly, the experimental group scored higher in attentional strategies, sleep management, fatigue, headaches, prospective memory, attention and memory, problem solving, prospective memory being the skill that had the greatest gain [13].

Similarly, another group of researchers conducted a randomized controlled study for the management of emotional and neuropsychological symptoms in war veterans. with comorbid post-traumatic stress disorder and who had suffered head trauma. Cognitive processing therapy (CPT) was used in combination with cogSMART in order to make a comparison between traditional CPT and CPT coupled with said program. The program lasted 12 weeks in sessions of 60 - 70 minutes, with participants being randomized to receive one or the other treatment. A measurement was made at three different times (baseline, post-treatment, that is 3 months after the intervention) and 6 months after the start of the study. Patients with a diagnosis of post-traumatic stress, mild to moderate TBI, cognitive complaints in at least 1 symptom were included in the Neurobehavioral Symptom Inventory test in cognitive area and who did not have medication for psychic symptoms The CPT program consisted of providing education about post-traumatic stress symptoms, change in beliefs, or distorted thoughts due to trauma; On the other hand, the CPT-COGSMART program included the same plan but parts of the computer program were added to improve compensatory cognitive strategies for attention, prospective memory and executive functioning that served to help a better performance in the follow-up of CPT therapy indications [14].

Regarding cognitive functioning after treatment, the processing speed had an improvement over time, but not there was a group by interaction time. There was a group by interaction time for attention and working memory, verbal learning in immediate memory that was characterized by an improvement to over time with the SMART CPT group in Compared with the CPT group, for delayed verbal recall there was a significant improvement over time, but no group by interaction time. In problem solving there was significant improvement compared to the CPT group, in the same way there was improvement over the time in cognitive flexibility and inhibition. Both groups showed a decrease in symptoms of post-traumatic stress disorder and post-concussion symptoms, however those who underwent the hybrid program showed greater improvement in neuropsychological evaluations of attention, learning/memory and novel resolution of problems. It is suggested that running a program of this type will not only improve symptoms of a post-traumatic stress disorder, but also by improving cognitive skills will help in the psychological care of people with this condition [14].

In Sweden, the Rehabilitation Medicine department of the Sahlgrenska University Hospital carried out a randomized controlled study in patients with working memory difficulties, using the COGMED computerized training program, for a period of 5 weeks. To carry out this research, 3 evaluations were made over time, which were baseline, the second evaluation was carried out later at 5 weeks of intervention and the last 3 months after treatment. To assess the baseline state of the patients as well as the effects of the treatment, both the verbal and visual working memory tests of the WAIS III test were applied, as well as the span of digits, {{1}} arithmetic and the proof of numbers and letters [15].

Similarly, brain function tests were used such as the Barrow Neurological Institute Screen that evaluates both quantitative and qualitative information and in which the total score is made up of seven related sub-scores with seven functions: language, orientation, concentration, visuospatial function, memory, affect and self-evaluation of performance. On the other hand, the subjects were also assessed with the DEX test for symptoms of executive dysfunction as well as anxiety and depression scales. The intervention program was developed in such a way that during 30 to 45 minutes 5 days a week for 5 weeks, the activities of the COGMED were provided within the memory aspects of work included maintenance of multiple stimuli at the same time, short delays during which the representation of the stimuli must be kept in working memory, unique sequencing of order of stimuli in each test and adaptation of the level of difficulty in relation to individual performance [15].

As a statistical analysis of the sample, there was no significant difference between control and experimental group in gender, age, time after damage, on the scale level of reaction, education and diagnosis or scores of the working memory scales. At baseline 1 in the groups there were no significant differences in gender or score on the level of reaction scale related to brain damage. Among the results reported in the digit span tests, both the control group and the experimental group improved significantly after training, however, the experimental group had a greater improvement Compared with the control group, in the same way this same group achieved the same performance as in measure two in measure 3, which indicates that the treatment effect stabilized over time [15]. In the working memory subscales there was significant improvement for both groups. In executive function, no differences were found between the two groups, nor improvement after the intervention, reporting serious dysexecutive problems justified by depression and anxiety in these patients. In the general cognitive assessment in the BNIS test there was significant improvement in the experimental group that was maintained until the third measurement, the same happened with the control group, however comparing the measurements of both groups, the experimental one had a greater increase, however, despite this, both groups continued to score below what was expected on this scale [15].

Quasi-experimental studies

Indianapolis researchers conducted a quasi-experimental study with control and experimental groups with a total of 20 participants in each. Its objective was to assess the effectiveness of a computer-assisted rehabilitation program called Bracy Process Approach in the areas of attention, problem solving, memory, and visuospatial ability [16]. To carry out this study in both samples men and women were included, the percentage of men being the majority in both groups. In this population the cause of trauma was due to factors such as motor vehicle accidents, blunt force injuries, and falls. There were no significant differences between both groups in demographic aspects related to age, years of education, periodicity in the evaluations and duration of coma, however, the time between the injury and the start of treatment as well as the duration of treatment if they had statistical differences [16].

The researchers used as tools of evaluation the subtests of WAIS-R, Subtest of the Neuropsychological Battery of Halstead Reitan, the Wechsler Memory Scale and Wechsler Memory Scale-Revised, Successive and Inverse Digits, Immediate and Delayed Logical Memory, Immediate and Delayed Visual Reproduction, Immediate and Delayed Pair Association, Trials A and B, as well such as the Wisconsin Card Sorting Test. The experimental group carried out its neuropsychological rehabilitation process at the Indianapolis Neuroscience Center, fulfilling the inclusion criteria: age (over 18 years old) schooling (9 years or more) and the requirement that the evaluation neuropsychological was given before and after computer-assisted cognitive rehabilitation (CACR). Control group subjects were gathered from the Neuropsychological Rehabilitation Center, the Indianapolis Neuroscience Center, the Community Hospital Department of Medical Psychology, and the Indianapolis NeuroRehab Center [16].

The methodology used in the study followed the following: Unlike the experimental group, the control group received fewer hours of the CACR program (2 hours a week for less than 4 weeks), and in both groups, variables such as severity of the damage associated with days in coma, time elapsed between the injury and the start of treatment, intervention time and data analysis in relation to demographic aspects. As a result of the research carried out, the statistical t tests showed that there was no significant difference between groups in relation to age and years of schooling. In the variables related to brain damage there were significant differences between time of injury and treatment extension, but not in aspects related to days in coma and periodicity of evaluations. When studying the variables associated with damage, it was found that there was a significant correlation in the experimental group between treatment time and intervention period after damage and the months of evaluation between tests [16].

There was no correlation between the CACR intervention time with the coma period, in the same way there was a negative correlation between the gain in scores in logical memory tests, intelligence test, verbal intelligence, completion of figures and digits and symbols and time after the injury, however in the control group there was a positive correlation between the periodicity in the evaluation and the scores obtained in layout of drawings. The extent of treatment did not correlate with any of the increased scores in the tests. Four domains were studied as covariates: attention, visuospatial ability, memory and resolution of problems with chronicity and extension of treatment, without finding significant differences between the groups ($p > 0.05$). There were no significant differences in the pre-treatment and post-treatment test scores [16].

Ruff., *et al*. [17] evaluated the effectiveness of the THINKable program for deficits in attention and memory in patients with severe brain damage, hoping that these results would be transplanted to daily life as well as to the psychometric tests. THINKable uses a multimedia system that displays images and uses digitized voice, likewise allows responses or the touch screen with a mouse. In order for the study to have greater methodological validity, the clinicians did not adapt the exercises for each patient, but rather prototypical exercise modules with different levels of difficulty were made. All participants were trained in the software providing feedback both within and between sessions. To carry out their research, they used a repeated measures design per trial group with two treatment conditions. The sample included 15 patients aged 16 to 50 years old who they had been included in the rehabilitation program after 6 months after presenting the brain damage; They were given a treatment of attention and memory that was concluded after 20 hours (divided into sessions of 2 hours per day) or until the participant reached an average performance in cognitive functioning of these aspects [17].

Subsequently, multiple measurements were made at intervals of 7 days, 3 days before and 3 after completing the training to assess progress as well as the effect of the attention and memory subcomponents. Measurements were made with Thinkable-type tasks but not the same as those of the program, as well as neuropsychological tests of attention and memory as digits and symbols of the WAIS R, the selective attention test 2 mas 7, Continuous Performance Test, Rey's Verbal Learning and Memory Test as well as corsi cube learning test; Similarly, behavioral assessments related to attention and memory were carried out, for which the family members also supported by providing information on what they observed [17].

At the end of the study in the computerized tasks of attention training there was a small but consistent increase and in the memory task an improvement of 2 to 5 percent was achieved post-training in only one of the 3 measurements. The percentage in the number of correct answers and in the response time also improved. Group A improved in attention tasks over group B and this function was maintained with its highest constant score in two measurement intervals (T5 to T7) However, group B had improvements despite the gains were not significant between one and another group; however, some subjects showed improvements in digits and symbols and in verbal and spatial memory tasks, but these were not significant in delayed. Similarly, at a general level, there was a significant gain in the patients' self-perception of improvement in care, the same situation that occurred with memory, although in reality the family members did not have the same perception. In general, this study observed improvements in mental control (attention) and logical memory, the remaining subsections did not reach significance [17].

On the other hand, other researchers carried out a study to assess the effectiveness of 4 different forms of cognitive training memory in people with post-traumatic amnesia. The sample included 26 adults between 18 and 45 years of age with a history of brain injury and impaired semantic memory. Participants joined the study 3 months after brain injury. Rivermead's behavioral memory test was used, which included those participants who had a performance below 15 points [18].

With a total of 10 sessions of 20 to 30 minutes each, 4 study groups were established: 1) those who worked on the computer-assisted program at their own pace and at a non-threatening environment, 2) a group in which immediate feedback was given, which was provided by the same computerized program, 3) another group presented content with routines real and 4) a group in which the computer program, due to its attractiveness, sought that the participants improve their attention [18].

All the groups had a significant improvement in their performance in memory tasks, unlike the control group that did not have any specialized intervention of this type. Of all the groups, the one with immediate feedback was the one with the best performance obtained through the performance indices of the computer program, so positive reinforcement in the face of performance improves memory function. Of the 4 groups, only the training by visual presentation was the one that presented the greatest increase in its percentage of performance in the Rivermead test. However, no significant improvement was obtained as measured by said test once the training was completed. The observed improvements were clinical [18].

Clinical trials

In a controlled study with a crossover design, the short- and long-term effects as well as the transfer into everyday life of a computerized working memory training program were analyzed in patients who suffered from limitations of said function after acquired brain damage of diverse etiology. They worked with a sample of 21 patients between the ages of 20 and 65 who were randomized, who reported difficulties in working memory and who scored with an index less than 80 on the WAIS III scale. Instruments were used to assess working memory in daily life, such as the PASAT 2.4 test; Interference Test Color-Word condition 4-Inhibition; Span board of Blocks forward and backward as well as the Listening Span Task; The Picture Span as well as questionnaires related to daily life and the effect that memory problems had on them [19].

Following a specific methodology, the authors planned that the program be It will be carried out in a total of 20 weeks, taking measurements at week 4 and 20 of the intervention. The training was done through a computerized QM program, in sessions of 45 to 60 minutes per day, 5 days a week, for 5 weeks, working on aspects of verbal and visuospatial tasks of working memory. The groups were distributed in a randomized manner in which some received training for 5 weeks and others did not. After, both groups were assessed, 4 more weeks were allowed to elapse, and a second assessment was performed for all subjects. After this time, the QM program of working memory is given to the control group. A follow-up was given that included an assessment after 20 weeks [19].

As results there was a significant difference at 4 weeks after training but not 20 weeks after it. At the 20-week follow-up assessment, a higher performance was observed on the PASAT test compared to the Direct Digits test in the paired T tests and for the Listening Span Task compared to the span of reverse digits. The performance in the progressive digit test did not change in the 20 weeks of follow-up in relation to the base line, the mean being 8.3 and 8.9 respectively [19].

Researchers from the Maastricht University of Mental Health and Neurosciences conducted a study with randomized parallel group in which they tried to assess the efficacy of a PEAT personal digital assistant (Planning and execution assistant and trainer) as a cognitive aid in people with acquired brain damage compared with pencil and paper methods in functions that would involve memory for daily life, planning capacity, functioning in daily life and quality of life [20].

On the other hand, they wanted to address the extent to which the use of a personal digital assistant (PDA) can reduce burden perceived by caregivers in case such devices improve functionality in the life of patients. Baseline measurements were made as well as at 8, 16 hours and 5 months later. A baseline measurement was performed and, after two weeks, another dual baseline measurement was performed to avoid practice biases in the performance of the verbal tests. Subsequently, the 16-hour training was applied and its result was assessed at 8 and 16 hours later, follow-up measurements were also given at 4 to 6 months later. Both the experimental group and the control group showed significant increases in mentioned skills [20].

The PEAT was used in the experimental group to train memory, planning and organization, attention and initiative, as well as programmed multi-step tasks. Different questionnaires related to goal achievement, instrumental and social activities, scales of perceived self-efficacy, questionnaire of satisfaction of the help provided by the electronic device were used as well as scales of depression, life satisfaction and questionnaires related to caregiver burden. Verbal learning tests, executive functioning, motor speed tests and working memory were used cognitively. As a result, a significant improvement was found in the visual-verbal learning test over time in delayed recall and the letter and digit substitution test in the experimental group, although there was no significant difference with the control group In both measurements, both groups also showed improvement in the achievement of established objectives between T0 and T2: the experimental group showed a mean increase of 45.2 (SD = 32.8) points, t (20) = 6.31, p .001, while the control group showed a mean increase of 36.7 points (SD 15.6), t (11) = 8.16, p, .001 . However, the scores did not differ significantly between the groups in T2 (p.> .05). This study concludes that the use of a personal digital assistant and pencil and paper materials in cognitive training are equally effective in populations with brain damage [20].

Case Study

Connor and Shaw [21] evaluated the use of computer games for brain training along with metacognitive strategies in people with brain damage. They conducted a case study with an n = 3, making pre- and post-intervention assessments using the Lumosity brain training program which focuses on a range of cognitive functions including processing speed, attention, memory, flexibility and problem solving. For their case study, these authors trained the subjects in the use of the Lumosity program in 24 sessions, encouraging the participants to use said game at home and, on the other hand, they were also given therapy for 12 weeks twice a week in 60-minute sessions to work on metacognitive skills and Lumosity exercises as well as free play from the same general training website. Of these cases, two were related with mild and severe TBI and another was a case of brain malformation that caused epilepsy. Specific neuropsychological batteries related to immediate and delayed verbal and auditory learning and Lumosity brain performance test were used in 7 composite score subtests. Performance in the pre- and post-assessment of psychosocial functioning, attention and visual memory, as well as cognitive performance of the 7 Lumosity subtests, were assessed. As a result, the 3 participants improved in the composite indices of the Lumosity and in the Woodcock-Johnson III battery except in the subtest of Pairs Cancellation of said instrument [21].

Conclusion

This review provides us with evidence that neuropsychological rehabilitation of executive functioning or mental functions related to said construct by means of a computer or computerized program provides an improvement, although not statistically significant, in individuals with acquired brain damage, however it is important to note that despite this study shows that these programs, in part, meet the proposed objective for which they are designed.

On the other hand, in this review we observed that the use of a computer is not more effective in cognitive rehabilitation compared to traditional methods of pencil and paper or neuropsychological therapy provided with the accompaniment of a specialist.

It is also clear that information technology, as an advanced tool that facilitates the life of the human being in all its areas, will have to continue to be just one more instrument in the field of neuropsychological rehabilitation since the complexity of the central nervous system is still much greater than that of technology, however sophisticated it may be.

This makes us think that the brain It is a system that in complexity surpasses computer systems, so its anatomical and functional reorganization requires multiple contributions related to health intervention. Among the benefits provided by these programs, the attractive qualities of stimuli with the use of technologies can be highlighted, which in the population with brain damage is an important factor that affects care focus and motivation of the participants, aspects that are altered in acquired brain injuries.

Our systematic review highlights the methodological variability of the neuropsychological rehabilitation programs in patients with TBI or acquired brain damage, which indicates that to date there is no consensus in the scientific community on the methodology to establish in the intervention of these patients. Variables such as duration of intervention, frequency with which treatment should be provided, type of instruments used in cognitive assessment, time taken to start treatment after damage, and functions mental objectives to be rehabilitated are some of the methodological aspects that differ in this type of research. We consider that methodological unanimity is needed, mainly related to the assessment instruments that are specific to each function, in the ideal time to start the intervention where spontaneous recovery does not act as a bias as well as in the type of exercises and number of sessions provided for this type of patient under a neurophysiological argument.

Likewise, we consider that the use of post-treatment assessment using neuroimaging techniques, would help to unify criteria in the methodology. Computer-based cognitive rehabilitation should be considered a support tool in the entire range of treatments that can be offered to patients with sequelae of head trauma or acquired brain damage regardless of etiology since using a single method would limit the patient from benefiting from comprehensive therapeutic management.

We believe that technological resources can be used in all types of patients with brain damage and that they should be introduced into therapy at the relevant time given the personal characteristics and medical conditions of the patient.

The limitations of our review are related to the number of included studies, so it cannot be as representative of the phenomenon studied as well as the variability of the design of the included studies. As lines of future research we can highlight the analysis of those software that include ecological exercises and correlate if these are useful in the lives of patients since most of the studies have focused on cognitive improvements knowing in advance that this does not necessarily imply generalization in everyday life.

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