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EFECTIVIDAD DE LA REHABILITACIÓN NEUROPSICOLÓGICA EN PACIENTES CON DAÑO CEREBRAL ADQUIRIDO

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Resumen. El objetivo de esta investigación es analizar la efectividad de la rehabilitación neuropsicológica en pacientes con daño cerebral adquirido (DCA). El DCA es una de las principales causas de discapacidad en el mundo actual, pudiendo producir tanto alteraciones cognitivas como físicas; llegando a limitar la calidad de vida de estas personas. Veinte participantes con deterioro cognitivo moderado participan en el estudio, 8 pertenecen al grupo control; mientras que los 12 restantes forman parte del grupo experimental, asistiendo dos sesiones semanales durante cuatro meses a rehabilitación cognitiva. Inicialmente se realiza una evaluación neuropsicológica para comprobar el estado de las funciones cognitivas de cada uno de los participantes; esta evaluación se repite a los 4 meses para analizar la efectividad de la rehabilitación. Los resultados muestran una mejora en aquellos participantes que han recibido la rehabilitación neuropsicológica en comparación con los pacientes del grupo control. A partir de estos datos, se establece una relación entre la rehabilitación neuropsicológica y la mejora de las funciones cognitivas que se encuentran dañadas. En conclusión, la rehabilitación cognitiva es fundamental para ayudar a los pacientes con DCA a mejorar las alteraciones de sus funciones cognitivas.

Palabras clave: Daño Cerebral Adquirido (DCA), Rehabilitación Neuropsicológica, Efectividad, Evaluación Neuropsicológica, Funciones Cognitivas.

EFFECTIVENESS OF NEUROPSYCHOLOGICAL REHABILITATION IN PATIENTS WITH ACQUIRED BRAIN INJURY

Abstract. The objective of this research is to analyze the effectiveness of neuropsychological rehabilitation in patients with acquired brain injury (ABI). ABI is one of the main causes of disability in today's world, being able to produce both cognitive and physical alterations; reaching to limit the quality of life of these people. Twenty participants with moderate cognitive impairment participate in the study, 8 belong to the control group; while the remaining 12 are part of the experimental group, attending two weekly sessions for four months to cognitive rehabilitation. Initially, a neuropsychological evaluation is carried out to check the state of the cognitive functions of each one of the participants; this evaluation is repeated at 4 months to analyze the effectiveness of the rehabilitation. The results show an improvement in those participants who

have received neuropsychological rehabilitation compared to patients in the control group. From these data, a relationship is established between neuropsychological rehabilitation and the improvement of cognitive functions that are damaged. In conclusion, cognitive rehabilitation is essential to help patients with ABI to improve the alterations in their cognitive functions.

Keywords: Acquired brain injury (ABI), Neuropsychological rehabilitation, Effectiveness, Neuropsychological Assessment, Cognitive functions.

Introduction

Acquired Brain Injury (ABI) refers, according to the World Health Organization (WHO), to a sudden brain injury that may be permanent or temporary and that takes place after birth and is not linked to degenerative or congenital diseases and may have origins in various causes such as traumatic brain injury (TBI), cerebrovascular accidents (CVA), tumors, anoxias; sometimes causing from functional disabilities to psychosocial maladjustment (WHO, Genoa, 1996).

Because ABI is characterized by its sudden onset compared to other neurological pathologies (degenerative or congenital), there is a sudden disruption in the life of both the affected person and their loved ones, as they see how their life changes abruptly without having been able to have previous strategies to help them cope with the situation. (Vara Arias & Rodríguez Palero, 2017).

Currently, ABI is one of the leading causes of death and disability in the world population. After suffering an ABI, it is very common to present cognitive deficits, among the most common and limiting ones are memory problems, executive functions, and attention. (García Molina, et al., 2015).

According to a 2015 report by the Spanish Federation of Acquired Brain Injury (FEDACE), in Spain there are 420,064 cases of people with ABI, of which 78% correspond to cases of stroke, while the remaining 22% correspond to other causes. Of those affected, 52.5% are women and 47.5% are men. On the other hand, of the total number of people with ABI, 65.03% are over 65 years of age. The annual incidence in our country stands at 104,071 new cases, of which 99,284 are due to stroke, 4,937 due to TBI, and 481 due to anoxia. Worldwide, 15 million people suffer a stroke every year; one third of them recover fully without any disability, another third have permanent disabilities that make it difficult for them to function in their daily lives, and the remaining third die. In relation to TBI, it is estimated that every year around 10 million cases occur worldwide. In industrialized countries, it mainly affects men between 16 and 35 years of age, with an incidence of between 200 and 300 cases per 100,000 inhabitants.

The sequelae can be grouped into 3 broad categories:

- Physical-motor impairments. Within this group, there are limitations in gait; balance; movement of the upper or lower extremities or both; decreased sensation, or hypersensitivity; fatigue, dizziness, tremors; loss of any of the senses.... (Moore Sohlberg & Mateer, 2017) .
- Emotional and behavioral disturbances. Aggressive behaviors may occur due to an inability to control their own impulses so that people become more uninhibited. On the other hand, the opposite case can occur, and that is that the person represses his behaviors in excess, showing apathy. Emotional alterations can manifest irritability, impatience, depression, emotional lability, greater sensitivity. In anosognosia, the person is not aware of the disability or problems that occur due to his injury. (McDonald , 2013) .

- Cognitive or intellectual alterations. As this is the type of sequelae to be evaluated in the present study, they are detailed in more detail below.

Memory is the cognitive area most often damaged after suffering an ABI. It is a complex function, encompassing general knowledge and the ability to hold it in memory and/or retrieve it (Sharp, Scott, & Leech, 2014) . The main memory disorder is amnesia, which occurs when memory is lost or altered for a short or long period of time. The rehabilitation of memory is influenced by various circumstances such as the severity of the injury; the age of the patient, as the older the person the less chance of memory recovery; and another important factor is that the intervention is carried out as soon as possible. (Cumming, Marshall, & Lazar, 2013) .

Among the language disorders, there may be a limitation in communication in written form, orally or both ways. The alteration in language comprehension is known as Wernicke's aphasia, while an alteration in expression is called Broca's aphasia. If the person has a limitation in reading, it is called alexia. On other occasions, there may be patients who manifest an alteration in being able to name or recognize objects, which is known as anomia. (Van Heugten C., 2013) .

A disturbance in attention leads to a worsening of concentration over a long period of time. (Brocalero & Pérez, 2013) . It is considered a multifactorial task as it can overlap with other neuropsychological domains, such as working memory, which belongs to executive functions. (Strauss, Sherman, & Spreen, 2006) .

In relation to orientation, it is related to the ability to determine our position in space and time at a specific moment. It is divided into 3 types: personal orientation, linked to information related to personal identity (name, age); spatial, related to information related to location (place where you are); and temporal, linked to time (day, month, year). (Ballesteros Tenrero, 2015) .

While the alteration of executive functions has an impact on the performance of complex tasks, task or activity planning, reasoning, behavioral inhibition (Chung C, 2013) .

In any patient with brain injury, cognitive functioning should be evaluated to check for possible damage that may have occurred, so a neuropsychological evaluation is performed in which it is advisable to interview the patient and close family members. (Lezak, 2013) .

Standard neuropsychological assessment includes tests of episodic memory, attention, cognitive processing speed, and executive functions, such as mental flexibility, planning, decision-making, inhibitory control, and organization. For patients with moderate to severe injuries, consciousness and judgment should be assessed to determine the patient's ability to function independently. (Rabinowitz & Levin, 2014) . The results of a neuropsychological evaluation provide information about which cognitive areas are impaired and which are preserved in the patient. (Wood & McMillan, 2013) .

In most cases, the neuropsychologist can recommend strategies to help the patient compensate for these deficits as well as advise the performance of neuropsychological rehabilitation (Vanderploeg, 2014) .

Neuropsychological Rehabilitation

Its objective is to minimize, compensate, and/or restore the possible alterations occurred as a result of the injury. (Ríos-Gallardo, Bonilla-Santos, Bonilla-Santos, González-Hernández, & Amaya-Vargas, 2016).

Cognitive alterations are one of the most frequent and disabling sequelae after suffering an ABI; therefore, taking advantage of the brain plasticity that the brain has, which is the ability to adapt to the changes produced by learning, experience, cognitive, and sensory

stimulation; cognitive rehabilitation is carried out to try to recover altered functions. (Carvajal-Castrillón & Restrepo P., 2013).

A factor that usually has an impact on the success of rehabilitation is the age at which the ABI occurs; this is considered by a study that shows that participants, who have a younger age, are those who have a greater improvement with treatment; this relationship between age and rehabilitation has an impact on an improvement in the area of attention, memory, and executive functions. (Puerta Cortés, 2017) .

Another study analyzed the effectiveness of a cognitive rehabilitation program in 10 patients with mild to moderate cognitive impairment for 4 months carrying out such rehabilitation; for this, they proceeded to divide them into two groups, the experimental and control. The results showed an improvement in immediate memory and global delayed recall in the experimental group in the cognitive measures; showing the effectiveness of rehabilitation in memory. (De los Reyes Aragón, Rodríguez Díaz, Sánchez Herrera, & Gutiérrez Ruíz, 2013).

In a study made up of 13 patients with TBI between the ages of 18-54 years, a cognitive rehabilitation program was carried out developing in 60 individual and 10 group sessions during a period of 5 months, comparing the pretest measures with the posttest and achieving significant gains in attention and executive functions as well as in memory although less noticeably. The improvement in the results is significant in the study group, while in the control group the results are similar or worse than the pretest. (Bonilla Santos, González Hernández, Amaya Vargas, Ríos Gallardo, & Bonilla Santos, 2016).

Another study analyzed the results of 10 patients with TBI, whose age ranged from 19 to 39 years, with a rehabilitation process of 6 months. The results obtained show a decrease in the alterations they initially presented. Regarding the global recovery of the patients, a reduction of 60% of the alterations has been obtained, being of 80% the reduction in the alteration of attention; while in the memory the alteration has been reduced in 45.05% of the intensity. Regarding the area of language, this same study shows a tendency to improve these results with rehabilitation. (León-Carrión, 2011) .

Regarding the results of cognitive rehabilitation on executive functions, a study was carried out with 19 participants with brain damage, 11 were part of the experimental group, and 8 of the control group. In the experimental group, 7 sessions of 2 hours were administered. The results after the intervention show positive effects on executive functioning in the experimental group, with a significant improvement in the Tower of London, generalizing the different strategies learned to activities of daily living (Levine, Schweizer, O'Connor, Turner, Gillingham, Stuss & Manly, 2011).

In a retrospective pre-post study conducted with 58 adult participants, 14 women and 44 men, participating in an intensive cognitive rehabilitation program for 4 months, shows that early onset of rehabilitation and higher cognitive functioning at the beginning are the best predictors of cognitive recovery. The results show an increase in functioning, from 33.6% to 85%, from the beginning to the end of the treatment. (Solís-Marco, Castellano Guerrero , Domínguez Morales, & León Carrión, 2014).

The analysis of the different studies allows us to infer that there are few studies focused on determining the effectiveness of neuropsychological intervention programs, especially due to the use of single case samples or with a small number of participants (Wall, Turner & Clarke, 2013).

It is also evident that most of the interventions in neuropsychological rehabilitation focus on a single cognitive component (e.g., memory or executive functions) and do not take into account the rest of the areas.

In addition, it is necessary that the intervention is adjusted to the characteristics of the individual and his or her damaged cognitive areas (Martínez-Martínez, Aguilar-Mejía, Martínez Villar, & Mariño García, 2014).

The general objective of the research is to analyze the effectiveness of neuropsychological rehabilitation in patients with acquired brain injury. And, as specific objectives, to check the differences obtained in the two records of scores of each cognitive function in each group, and the difference in effectiveness between patients who perform cognitive rehabilitation as a function of age.

Method

Participants

The sample is made up of 20 participants with ABI, aged between 20-88 years. Of these patients, 12 underwent neuropsychological rehabilitation, forming part of the experimental group, while the other 8 belonged to the control group. The assignment to these two groups has been made by convenience, selecting those people who wished to participate as volunteers, although always fulfilling the requirement of having an ABI. Of the 12 people receiving the treatment, 5 had suffered TBI, 5 strokes, 1 brain tumor, and 1 anoxia. Of these persons belonging to the experimental group, 8 are women and 4 are men; the minimum age of this group is 30 years, while the maximum is 71 years. The mean age of the group was 55 years, with a standard deviation of 13 years.

As for the 8 people belonging to the control group, they have been assigned because they present some type of ABI but do not carry out any cognitive rehabilitation. Within this group, 5 are men and 3 are women; 2 of whom have suffered a stroke, 2 TBI, 2 brain tumors, and 2 anoxias. With regard to this group, the minimum age is 20 and the maximum 88 years, with a mean age of 52 years and a standard deviation of 22 years.

In relation to the inclusion criteria that were taken into account for the selection of the sample, the following are found.

-Diagnosis of cognitive impairment.

-Users in a neurological rehabilitation center.

-Seniors.

The only exclusion criterion was the absence of cognitive impairment.

Instruments

To assess the clinical changes in the different cognitive functions, tests were administered to each of the participants at the beginning and after the neuropsychological rehabilitation program.

Rey's Complex Figure Copy Test (Rey, 1959) .

It consists of copying a drawing and later reproducing it using the memory of the previous copy as a reference. This test consists of 3 sections. The figure is divided into 18 parts. The information about its score ranges from 2 to 0 according to the combination between the criterion of accuracy and the criterion of location. The maximum score is 36 points. In the present study, only the scores obtained in immediate and delayed recall are taken into account so that the impairment of visual memory is assessed.

Trail Making Test (Partington, 1983) .

It is divided into: Part A, where you have to join 25 numbers randomly distributed on a sheet; and Part B, which consists of joining 12 numbers and 12 letters in alternate order. The score will depend on how many seconds it takes to complete it correctly and your age. The purpose of this test is to assess flexibility and visual-motor speed.

Free and Cued Selective Reminding Test (FCSRT) (Buschke, 1984) .

The patient is presented with 4 pictures and 16 words which he will have to learn and notice that each word belongs to a different category. He will be told a category, and he will have to say with which word it is related. Afterwards, he will have to repeat all the words that he evokes, giving him the category of those words that he does not remember. A total of 3 tests are carried out with free or facilitated recall; and a last one, delayed recall, which is administered 30 minutes later. This test evaluates verbal memory.

Direct and indirect digit test (Wechsler, 1987) .

It was administered from the WAIS-III Battery. The task consists of reading aloud to the participants a series of numbers, progressively increasing the series, until they commit two consecutive failures within the same span. It is applied in both direct and inverse directions. The range of scores in direct digits is from 0 to 9 and in inverse digits from 0 to 8. This test evaluates the impairment in attention and working memory.

Barcelona Test (Peña-Casanova, 1991) .

First cognitive exploration instrument to analyze the neuropsychological state developed in Spain. It consists of a total of 106 subtests in 42 sections. The duration of the full test is 3 hours, so in this case we proceed to perform a reduced version of it with the following subtests: orientation (person, place, time); visual-verbal naming (series of images where the participant says what he sees); categorical evocation in associations (name of animals in 1 minute, evaluates executive functions); verbal comprehension (imitate verbal commands, simple and complex movements), reading text, copying sentence. These 3 subtests evaluate language; verbal abstraction (similarities and differences between 2 words, evaluates verbal fluency).

Procedure

With regard to ethical aspects, before starting the research, each participant is given an information sheet explaining what this work consists of. Once they have read it, they are asked to communicate any doubts or clarifications they may need. Next, the informed consent is given in accordance with the provisions of Law 15/1999 on the Protection of Personal Data. Each person gives in writing their willingness to participate in this study, being guaranteed the confidentiality of all the information provided and having the possibility in the case that it requires it to be able to renounce their participation, without any inconvenience.

Initially, an assessment is made of the essential aspects of global cognitive functioning through the administration of the aforementioned tests described above, with the aim of finding out how the patient's cognitive functioning is after suffering an ABI.

These results provide the necessary information to carry out an intervention program for the experimental group in which rehabilitation consists of activities based on strategies and techniques of neuropsychological rehabilitation of memory, attention, language, orientation, and executive functions. These exercises are carried out in a personalized way depending on the areas that are affected after the first neuropsychological evaluation since each person is unique, and even if they have suffered the same pathology as another person, the same brain area is not always altered; so if for example there is an alteration in memory and attention, most of the exercises will be referred to these 2 areas, although the other areas are also worked on so as not to neglect them, trying to maintain them and even improve them. The exercises are both pencil and paper and computerized. The participants in the study are divided into two groups, the experimental group, which carries out the cognitive rehabilitation

with two individual weekly sessions of one hour for four months; and the control group, which does not carry it out.

Neuropsychological rehabilitation takes place in a natural context, avoiding possible distractions and providing the necessary materials for each session (sheets of paper, pencils, computer, etc.).

The activities that are carried out for rehabilitation will depend on cognitive function:

- Memory. To work on semantic memory, exercises such as matching elements with the category to which they belong are carried out. In episodic memory, the most common exercise consists of the patient reading a story and then, without looking, being able to answer questions related to the text. To enhance immediate memory, exercises consisting of repeating lists of words and numbers are performed. In relation to recent memory, immediate verbal memory exercises are performed, which consist of reading a list of words to the patient and having him/her repeat them; and immediate visual memory exercises, which consist of recognizing objects observed in a drawing. To rehabilitate working memory, the patient is asked to write the days, months of the year, etc. both directly and inversely, or to read numbers aloud and repeat them.
- Orientation. In the case of personal orientation, a series of questions are asked related to the person, such as name, age, where he/she lives, etc. In relation to spatial orientation, questions related to location, where we are, city, country, etc. are asked. And, in reference to temporal orientation, they are asked a series of questions related to temporal data, what day of the week it is, month, year, hour, etc.
- Language. In order to rehabilitate written language, dictation exercises, description of objects, and experiences lived by the patient are carried out; one of the most effective exercises is the word escape game, which consists of completing the words that are incomplete. On the other hand, for the rehabilitation of oral language, exercises of reading aloud, description of images, or experiences are carried out.
- Attention. To rehabilitate attention, cancellation task exercises are carried out where, if the child is asked to simply mark the letter E, selective attention is strengthened; if, in addition, he/she is asked to do it in a specific time, processing speed is worked on. If the child is asked to mark all the letters A until the word "change" is said to him/her, which is when he/she has to move on to crossing out the letters E, successively giving him/her other indications, alternating attention is worked on. To rehabilitate selective and sustained attention, there is the alphabet soup exercise and to look for differences between two images.
- Executive functions. They are divided into categorization, where the patient has to divide a list of words into groups, and then name the group; in seriation, where sentences have to be ordered so that they have a logical sequence; in planning, where the patient has to describe the steps that are necessary to carry out a specific action (for example, preparing a holiday); and in initiative, where the patient has to write the name of 15 countries or write animals that have 7 letters.

After 4 months of neuropsychological rehabilitation, the initial evaluation is administered to check the changes that have occurred and to analyze the effectiveness of neuropsychological rehabilitation in patients with ABI, verifying the differences that have occurred between the experimental group and the control group. In addition, it is checked if there are differences taking into account age.

Data analysis

To test whether neuropsychological rehabilitation improves the cognitive functions of memory, language, attention, orientation, and executive functions in patients with ABI compared to those who have not undergone such rehabilitation, t-tests were performed for independent samples in which there were 2 groups (experimental and control) and 2 evaluation times (pre- and post-measurement). A confidence level of 95% was established, and, therefore, a margin of error of 5% ($p<0.05$). The Student's t-test for independent samples was used in all cases since the principle of normality was fulfilled, verified with the shapiro-wilk statistic, used because it was a sample of 20 participants, and the principle of homogeneity of variances, verified with Levene's test, so it was not necessary to perform non-parametric tests. The test variables were the scores obtained in the different cognitive functions; while the grouping variable was the group to which the patients belonged (experimental and control). Likewise, repeated measures ANOVA was performed to check if age influences the improvement from pre to post in the experimental group.

Statistical analyses were performed with SPSS version 22.0 statistical software.

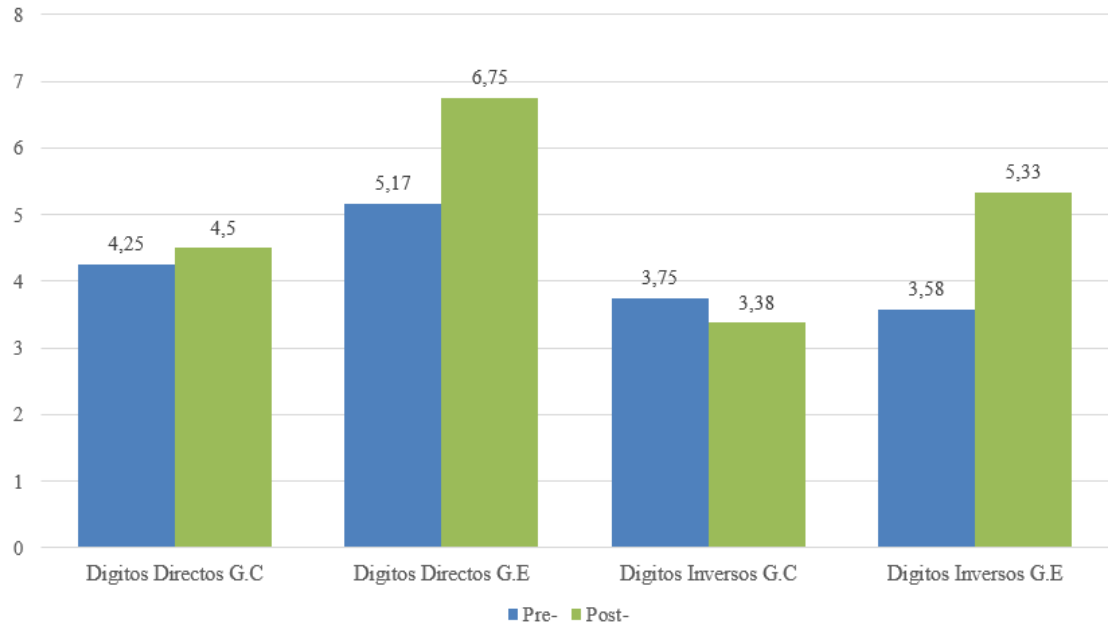
Results

The data obtained in SPSS are analyzed through a comparison of means to check if there are significant differences between the experimental and control groups with respect to the variables of attention, memory, language, orientation, and executive functions in the pre- and post-measures.

First, there are no significant mean differences in the direct digits dimension in the pre-measure between both groups (t (18)=1.19, $p=0.249$); nor in inverse digits (t (18)=-0.27, $p=0.789$). Regarding the post-measures, there are significant differences in the direct digits dimension between both groups (t (18)=4.25, $p=0.000$); and in the inverse digits dimension (t (18)=3.53, $p=0.002$). In conclusion, there is a significant improvement in attention and working memory when performing neuropsychological rehabilitation since the experimental group obtains a higher score, as shown in Figure 1.

Figure 1

Comparison of Attention and Working Memory pre and post in G.C and G.E.



Secondly, there are no significant differences in means in the pre-measure in the immediate verbal memory dimension between both groups (t (18)=0.34, $p=0.736$); nor in total free verbal memory (t (18)=0.68, $p=0.506$); nor in total verbal recall (t (18)=1.54, $p=0.140$); nor in deferred free verbal recall (t (18)=0.49, $p=0.632$); nor in deferred total verbal recall (t (18)=1.48, $p=0.155$). Likewise, there are no mean differences in the pre-measure in the two dimensions of visual memory neither in immediate visual memory (t (18)=-0.35, $p=0.729$); nor in deferred visual memory (t (18)=-0.44, $p=0.665$).

Regarding the post-measures, there are significant differences in the immediate verbal memory dimension between both groups (t (18)=3.67, $p=0.002$); in total free verbal memory (t (18)=4.97, $p=0.000$); in total verbal recall (t (18)=5.29, $p=0.000$); in delayed free verbal recall (t (18)=6.04, $p=0.000$); and in delayed total verbal recall (t (18)=6.12, $p=0.000$), as shown in Figure 2. Likewise, there are also mean differences in the post-measure in the two dimensions of visual memory, in immediate visual memory (t (18)=2.20, $p=0.041$); and in deferred visual memory (t (18)=2.18, $p=0.042$), as reflected in Figure 3. In conclusion, there is a significant improvement in all dimensions of both visual and verbal memory when performing neuropsychological rehabilitation.

Figure 2

Comparison of Verbal Memory in CG and EG measured after

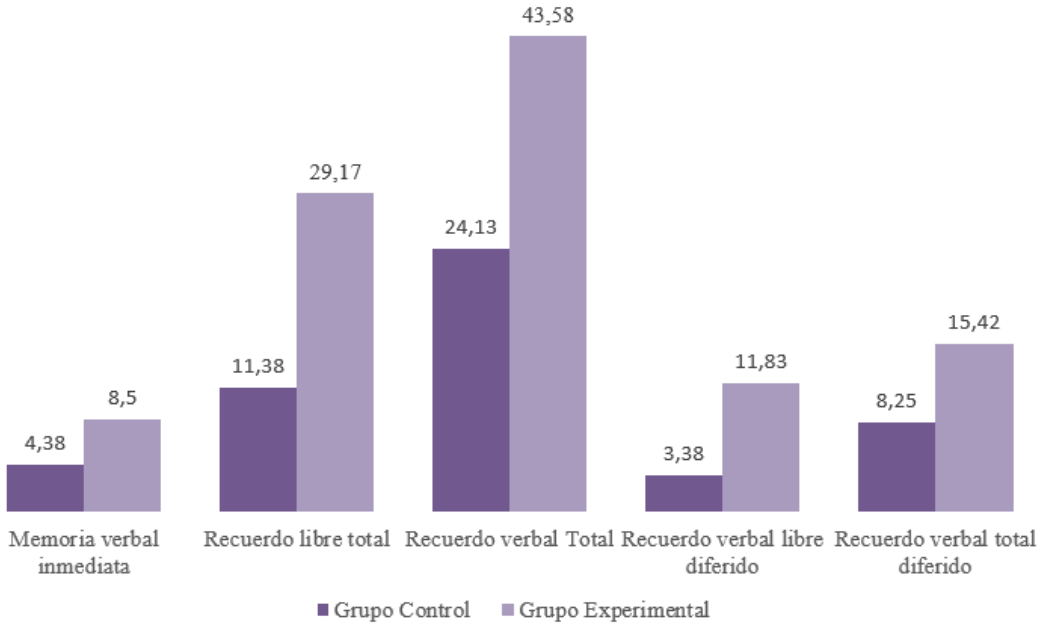
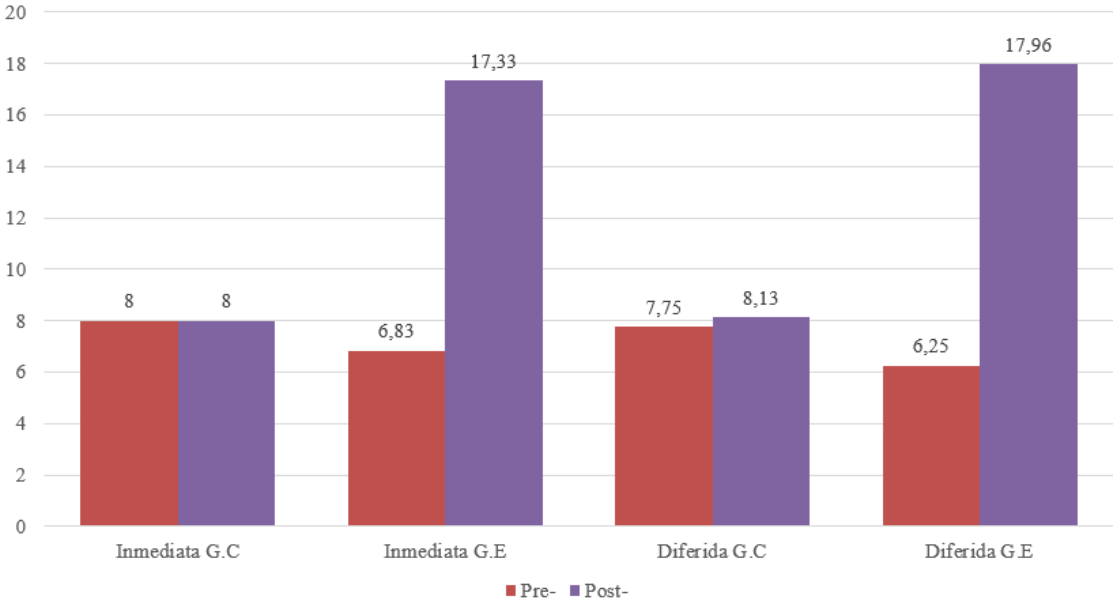


Figure 3

Comparison of pre- and post- Visual Memory in CG and EG

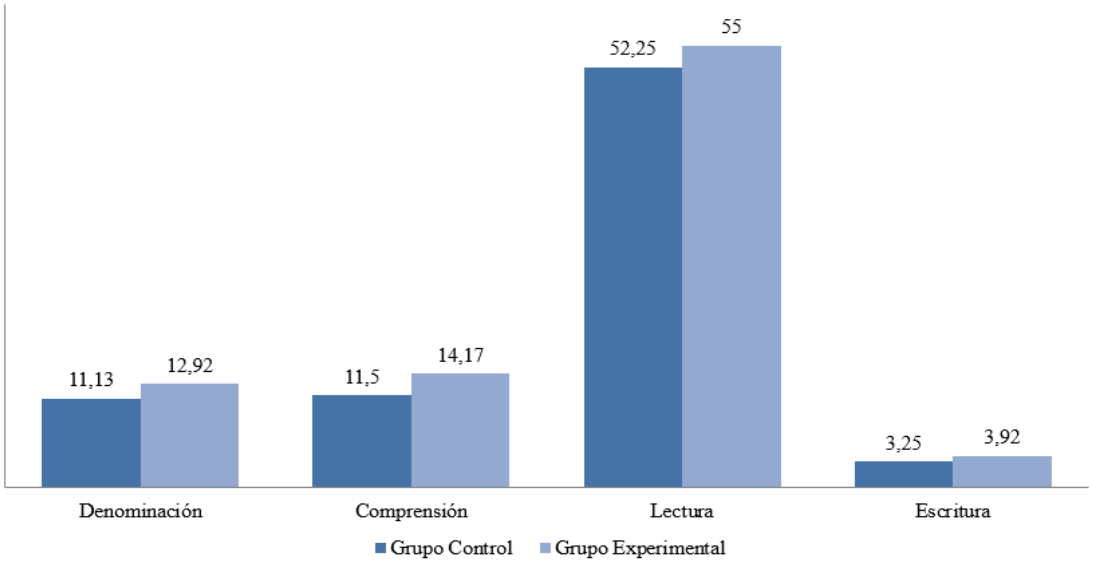


Thirdly, there are no significant mean differences in the pre-measure in the naming dimension between both groups (t (18)=1.17, $p=0.256$); nor in comprehension (t (18)=-0.59, $p=0.560$); nor in reading (t (18)=-0.31, $p=0.762$); nor in writing (t (18)=-0.16, $p=0.871$).

Regarding the post-measures, there are significant differences in the naming dimension between both groups (t (18)=2.41, p=0.027); in comprehension (t (18)=2.27, p=0.036); and, in reading (t (18)=3.63, p=0.002); on the contrary, there are no significant differences in writing (t (18)=1.16, p=0.260) with both groups scoring similar, as shown in Figure 4. In conclusion, there is a significant improvement in all language dimensions after neuropsychological rehabilitation, with the exception of the writing dimension.

Figure 4

Comparison of CG and EG language in post measurement

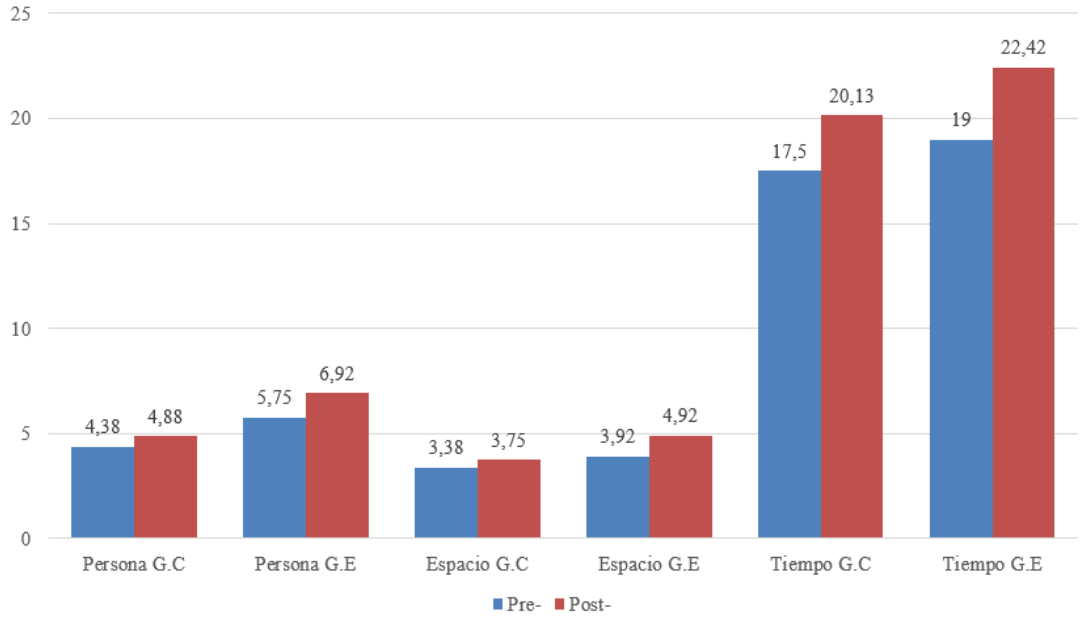


Fourthly, there are no significant mean differences in the pre-measure in the person orientation dimension between both groups (*t* (18)=1.92, *p=0*.070); nor in space (*t* (18)=0.88, *p=0*.391); nor in time (*t* (18)=0.69, *p=0*.498).

Regarding the post-measures, there are significant differences in the person orientation dimension between both groups (*t* (18)=2.38, *p=0*.003); in space (*t* (18)=2.27, *p=0*.006); and in time (*t* (18)=2.11, *p=0*.049), although in the latter case not as significantly as in the other two orientation dimensions, as shown in Figure 5. In conclusion, there is a significant improvement in the orientation dimensions when neuropsychological rehabilitation is performed.

Figure 5

Comparison of Pre and Post Orientation in CG and EG

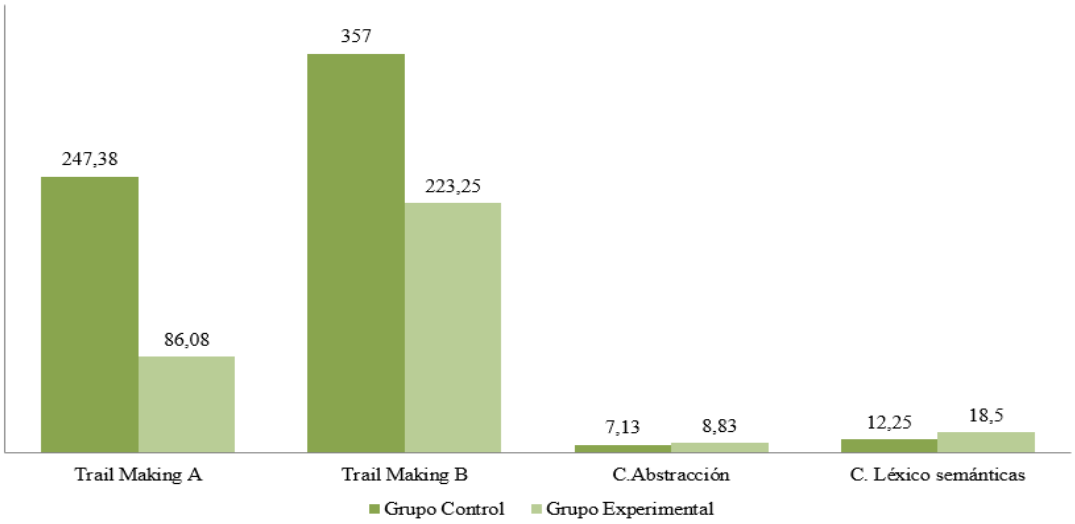


Finally, with respect to the pre-measurement in the executive functions dimension of Trail Making A, there is no significant difference between the means of both groups (t (18)=-1.73, $p=0.101$); nor in Trail Making B (t (18)=0.07, $p=0.941$); nor in abstraction abilities (t (18)=0.86, $p=0.399$); nor in lexical-semantic abilities (t (18)=0.42, $p=0.682$).

Regarding the post-measures, there are significant differences in the executive functions dimension of Trail Making A between both groups (t (18)=-2.46, $p=0.024$); and in Trail Making B (t (18)=-1.66, $p=0.015$); in this case both in Trail Making A and B, having a lower score is linked to a better performance in this section, so that carrying out the rehabilitation has led to a decrease in the time spent, thus improving the result. On the other hand, significant differences are also shown in abstraction skills (t (18)=3.08, $p=0.006$); and in lexical-semantic skills (t (18)=2.99, $p=0.008$). In conclusion, there is a significant improvement in all dimensions of executive functions after neuropsychological rehabilitation, as shown in Figure 6.

Figure 6

Comparison of post averages in Executive Functions



Also, it was analyzed by repeated measures ANOVA whether age influences the improvement from pre to post in the experimental group.

First, regarding the attention and working memory dimension, there are differences between the pre and post measures in direct digits, (*F* (1.00, 10.00)=16.85, *p=0*.002, η2=0.63), scoring the post measure (M=6.75, SD=1.14) higher than the pre measure (M=5.17, SD=2.08); and, in reverse digits, (*F* (1.00, 10.00)=8.80, *p=0*.014, η2=0.47), scoring the post measure (M=5.33, SD=1.30) higher than the pre measure (M=3.58, SD=1.56). In conclusion, the age at which cognitive rehabilitation is carried out influences the improvement of scores in the dimension of attention and working memory.

Second, regarding the verbal memory dimension when no cues are provided, there are statistically significant differences between the pre and post measures in immediate verbal memory, (*F* (1.00, 10.00)=9.33, *p=0*.012, η2=0.48), scoring the post measure (M=8.50, SD=2.84) higher than the pre measure (M=4.67, SD=2.77); in total free recall (*F* (1.00, 10.00)=8.02, *p=0*.018, η2=0.44), scoring the post measure (M=29.17, SD=8.42) higher than the pre measure (M=13.92, SD=8.60); and in delayed free recall (*F* (1.00, 10.00)=6.94, *p=0*.025, η2=0.41), scoring the post measure (M=11.83, SD=2.76) higher than the pre measure (M=4.42, SD=3.78). On the other hand, when cues are provided to the participants, there are no statistically significant differences between the pre and post measures in total recall (*F* (1.00, 10.00)=0.00, *p=0*.996, η2=0.00); and neither in total delayed recall (*F* (1.00, 10.00)=0.92, *p=0*.361, η2=0.08). In relation to the visual memory dimension, there are statistically significant differences between the pre and post measures in immediate visual memory (*F* (1.00, 10.00)=11.82, *p=0*.006, η2=0.54), scoring the post measure (M=17.33, SD=9.52) higher than the pre measure (M=6.83, SD=5.63); and in delayed visual memory (*F* (1.00, 10.00)=8.34, *p=0*.016, η2=0.46), scoring the post measure (M=17.96, SD=10.00) higher than the pre measure (M=6.25, SD=6.17). In conclusion, the age at which neuropsychological rehabilitation is carried out has an influence on the improvement of both visual and verbal memory, with the exception of when the latter is provided with cues in which age does not seem to have an influence.

Thirdly, with respect to the language dimension, there are no statistically significant differences between the pre and post measures in naming (*F* (1.00, 10.00)=0.86, *p=0*.377, η2=0.08); nor in comprehension (*F* (1.00, 10.00)=0.14, *p=0*.718, η2=0.01); nor in reading (*F*

(1.00, 10.00)=4.62, *p=0.*057, η2=0.32). On the other hand, there were statistically significant differences between the pre and post measures in writing (*F* (1.00, 10.00)=6.05, *p=0.*034, η2=0.38), with the post measure (M=3.92, SD=0.99) scoring higher than the pre measure (M=3.07, SD=0.89). In conclusion, the age at which cognitive rehabilitation is carried out has no influence on the improvement of 3 of the 4 dimensions of language; except for the writing dimension where age does seem to have an influence on the improvement.

Fourth, in terms of the orientation dimension, there are no statistically significant differences between the pre and post measures in orientation in person controlling for age (*F* (1.00, 10.00)=2.72, *p=0.*130, η2=0.21); nor in space (*F* (1.00, 10.00)=0.04, *p=0.*852, η2=0.01); nor in time (*F* (1.00, 10.00)=0.00, *p=0.*984, η2=0.00).

In conclusion, the age at which neuropsychological rehabilitation is carried out does not influence the improvement of scores in the 3 dimensions of orientation.

Finally, with respect to the dimension of executive functions, there are no statistically significant differences between the pre and post measures in Trail Making A (*F* (1.00, 10.00)=0.69, *p=0.*425, η2=0.06); nor in Trail Making B (*F* (1.00, 10.00)=1.09, *p=0.*320, η2=0.10); nor in abstraction abilities (*F* (1.00, 10.00)=0.22, *p=0.*647, η2=0.02). On the other hand, in lexical-semantic abilities there are statistically significant differences between the pre and post measures (*F* (1.00, 10.00)=5.34, *p=0.*044, η2=0.35), with the post measure (M=18.50, SD=3.85) scoring higher than the pre measure (M=12.25, SD=3.96). In conclusion, the age at which cognitive rehabilitation is carried out does not influence the improvement of scores in 3 of the 4 dimensions of executive functions; only in the dimension of lexical-semantic abilities where age does seem to have an influence.

Discussion and conclusions

The present study aimed to test the efficacy of neuropsychological rehabilitation in patients with ABI.

From the results obtained, there are two main analyses that can be obtained from this study. On the one hand, it has been evaluated whether the participants belonging to the experimental group show an improvement in the results after performing neuropsychological rehabilitation for 4 months in comparison with those patients belonging to the control group, and who, therefore, have not carried it out. And, on the other hand, it has been analyzed whether in the experimental group the improvement of scores from pre to post measures has been influenced by age.

Regarding the first of the analyses, the results found show a significant improvement in those patients who have undergone neuropsychological rehabilitation compared to those who have not in all the dimensions analyzed. This indicates that neuropsychological rehabilitation is effective in improving the performance of cognitive functions in patients with ABI, which coincides with the study conducted by Bonilla Santos, González Hernández, Amaya Vargas, Ríos Gallardo, & Bonilla Santos (2016).

The results obtained in the present research concretely show an improvement in the dimension of memory, coinciding with the findings of De los Reyes Aragón, Rodríguez Díaz, Sánchez Herrera, & Gutiérrez Ruíz (2013). In relation, there is the study by Solís-Marco, Castellano Guerrero, Domínguez Morales, & León Carrión (2014), who found a significant improvement in short-term memory; while in long-term memory and executive functions significant improvements were observed in the third and second month respectively. In the present research, we can only see that there has been an improvement in these areas but not in the month in which they occur.

Regarding the significant improvement in the attention dimension, there are studies that support this improvement through neuropsychological rehabilitation with León Carrión

(2011); and, Bonilla Santos, González Hernández, Amaya Vargas, Ríos Gallardo, & Bonilla Santos (2016).

In relation to the language dimension, in the present research the improvement has been significant in 3 of the 4 parameters that have been analyzed, since the only one in which there has been no improvement has been in writing. In reference to these data obtained, we find the study carried out by León Carrión (2011), which shows an improvement in language scores in general, not making distinctions by parameters as has been done in the present research.

The progress in the results of the executive functions dimension coincides with the study conducted by Martínez-Martínez, Aguilar-Mejía, Martínez Villar, & Mariño García, (2014).

Finally, the area of orientation shows an improvement in person, space and, to a lesser extent, time, and it is not possible to compare it with previous studies due to the lack of research in this area.

Regarding the second analysis, it was possible to demonstrate in the experimental group the influence of age on the improvement of scores from pre to post in the cognitive functions of memory without the facilitation of both verbal and visual cues; in both direct and inverse attention; in executive functions, only in the dimension of lexical-semantic abilities; and in language, although exclusively in the dimension of writing. On the other hand, no influence of age has been demonstrated in the improvement of scores in any of the dimensions of orientation; nor in 3 of the 4 dimensions of executive functions; nor in 3 of the 4 dimensions of language. In relation to these data, studies by Puerta Cortés (2017) and García Molina, Roig Rovira, Enseñat Cantallops, & Sánchez Carrión (2014), state that one of the best predictors in the improvement of cognitive functions altered after an ABI is age, demonstrating the relationship between age and neuropsychological rehabilitation with the improvement in the area of memory, attention, and executive functions. In relation to the research carried out, this coincides with the findings of the study since both memory and attention show an influence of age on the improvement; although in the case of the improvement in executive functions, this influence is only shown in one of its dimensions. In reference to the cognitive areas of language and orientation, which do not seem to be influenced by age, there are no studies that carry out such research to be able to compare them.

On the other hand, the results should be analyzed taking into account some limitations and future lines of research.

Firstly, the short duration of the intervention, which, although it shows satisfactory results in this aspect, it would be advisable to carry out an intervention for a longer period of time as well as to carry out a follow-up of its projection.

Secondly, the size of the sample since the small number of patients analyzed means that these results can only be generalized for the time being to this type of population and to the duration of the intervention. A recommendation in this sense would be to carry out experimental designs with larger samples in the future.

Thirdly, as the sample was small, it was not possible to use more statistics or to analyze other variables that would have been interesting, such as gender and the pathology of ABI suffered by the patient in comparison with the difference in effectiveness that could have been experienced.

Likewise, there is a lack of information regarding the clinical profile of the participants (functional status, time elapsed since the ABI, origin, etc.), which should be taken into account in future research due to its possible influence on the results obtained.

Another possible limitation is the heterogeneity in the rehabilitation procedure since a standard program has not been applied to all participants equally, although it has been done in

this way with the aim of improving the areas that were most affected in the participant, thus adapting the intervention to the person.

In conclusion, neuropsychological rehabilitation in patients with ABI is effective for the improvement of cognitive functions that have been altered such as attention, memory, language, orientation, and executive functions. Specifically, according to the findings, performing neuropsychological rehabilitation and the age at which it is carried out is associated with a better response to treatment. Therefore, it is inferred that after an ABI it is necessary to carry out neuropsychological rehabilitation aimed at improving the cognitive areas that have been affected, being fundamental in this way the inclusion of specialized neuropsychological treatments in the different multidisciplinary programs of rehabilitation of brain damage.

These results should serve to broaden the conception of brain plasticity and its potential for cognitive recovery after suffering an ABI, which suggests the need to highlight the important role of neuropsychological rehabilitation in order to make it more visible since such rehabilitation helps to guide the improvement of plasticity. In this sense, the use of neuroimaging techniques can provide an objective measure to evaluate the effectiveness of neuropsychological rehabilitation.

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