Outcomes of a multicomponent intervention on occupational performance in persons with unilateral acquired brain injury

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Summary

Complications after unilateral acquired brain injury (ABI) can affect various areas of expertise causing (depending on the location of the lesion) impairment in occupational performance. The aim of this study was to analyze and compare the concepts of occupational performance and functional independence, both before and after a multicomponent intervention including occupational therapy, in persons with unilateral brain damage.

This was a longitudinal quasi-experimental pre-test post-test study in a sample of 58 patients with unilateral brain injury (28 with traumatic brain injury and 30 with ischemic stroke). The patients' level of independence was measured using the short version of the International Classification of Functioning, Disability and Health. We also measured quality of performance using the Assessment of Motor and Process Skills. The findings of this study showed that patients with injury in the right hemisphere improved more than those with left hemisphere damage ($p<0.001$).

All the patients with ABI, especially those with right-sided injury, derived benefit from the multicomponent intervention, except in the area of motor skills. More research is needed on the specific techniques that might address such skills.

KEY WORDS: functional independence, hemispheric specialization, laterality, quality of performance, stroke, traumatic brain injury.

Introduction

Hemispheric specialization and laterality have been studied in many animal species. Hemispheric specialization refers to differences both in anatomical structure and in functional output between the cerebral hemispheres (Lust et al., 2011; Johnson-Frey et al., 2005; Mapstone et al., 2003). The vast majority of the human population clearly uses one hand as the dominant hand for activities such as writing or throwing objects. Approximately 90% of the population is right-handed. The arm of the dominant hand has been found to show differences, compared with that of the non-dominant one, in parameters such as muscle strength and bone density (Steele and Uomini, 2005). Each hemisphere controls the activity of the other side of the body, and each lobe has defined functions that, together, allow the holistic functioning of the brain. Knowledge of neural networks together with data from electrophysiological studies of interhemispheric transmission support the importance of the corpus callosum in the cooperation between the two cerebral hemispheres and illustrate the concept of brain lateralization (Nowicka and Tacikowski, 2011; Korsnes and Magnussen, 2007).

It is widely recognized that persons with right- and those with left-sided brain injury differ in terms of the incidence and severity of the resulting cognitive-perceptual impairment. Persons with right hemisphere (RH) damage are described as having neglect disorders, visual-spatial problems and left-sided motor impairments, while those with left hemisphere (LH) damage are more commonly described as having apraxia, aphasia and right-sided motor impairments (Lundervold et al., 2005; Poole et al., 2009).

Scientific literature suggests that the level of functional independence between persons with right- and left-sided brain damage may not be similar. Indeed, while some studies (Árnadóttir et al., 2010; Bernspång and Fisher, 1995; Rexroth et al., 2005; Titus et al., 1991) failed to find differences between these groups, others did find differences (Poole et al., 2011; Chestnut and Haaland, 2008; Hartmann et al., 2005), reporting that persons with right-sided brain injury show better occupational performance than persons with left-sided

brain damage.

The aim of this study was to analyze and compare the concepts of occupational performance and functional independence in persons with unilateral acquired brain injury (ABI). The ABI patients studied comprised persons with traumatic brain injury (TBI) and patients with cerebrovascular disease, specifically ischemic stroke (Ihle-Hansen et al., 2012). The patients were also grouped by damaged hemisphere (RH or LH) in order to explore possible differences in post-intervention outcome between these two groups. Participation in and quality of performance of activities of daily living (ADL) were measured before and after a multicomponent intervention including occupational therapy (MCI-OT).

Materials and methods

Research design

This was a single-blind, longitudinal quasi-experimental pre-test post-test study conducted over a period of 12 months. Participants were enrolled and received the intervention (MCI-OT) on an ongoing basis. After they had provided informed consent, we evaluated the 58 participants (28 individuals with TBI and 30 with ischemic stroke), all with unilateral right-sided or left-sided brain injury, considering: i) the full sample, ii) the sample divided into diagnostic groups, and iii) the sample divided by affected hemisphere.

Participants

A convenience sample of patients with ABI was recruited from two neurorehabilitation clinics in Madrid. We screened 62 people who had clinical evi-

dence of unilateral brain damage (one year post onset) and who were over the age of 18 years. To be included, potential participants had to i) have unilateral brain injury confirmed by the neurological service report that included neuroimaging findings, and ii) be right-handed. Doctors and neuropsychologists from the two clinics were responsible for selecting the sample. Four people were excluded because they met one or more of the following exclusion criteria: i) disease evolution time of less than one year, ii) other central nervous system disorders (tumors, anoxia, etc.), iii) cardiorespiratory impairments, iv) neurodegenerative disorders, v) severe brain damage or a score of 6 or higher on the Global Deterioration Scale (GDS) (Reisberg et al., 1982), and vi) severely impaired consciousness or a score of 8 or lower on the Glasgow Coma Scale (GCS) (Gill et al., 2004). The final sample was composed of 58 post-acute patients, 36 men and 22 women, with a mean age of 47 years (Table I).

Instruments and measures

The daily activities of all the participants were evaluated using the short version of the International Classification of Functioning, Disability and Health (ICF), and the Assessment of Motor and Process Skills (AMPS).

The ICF is the WHO's framework for measuring health and disability at both individual and population levels (WHO, 2001). We evaluated 23 domains proposed by the Spanish White Paper on the Care of Dependent People (IMSERSO, 2005), all of which belong to the ICF's *Participation* and *Activities* components. The 23 domains were scored on a scale of 0 to 4, where: 0=no impairment, 1=mild impairment, 2=moderate impairment, 3=severe impairment, and 4=complete

Table I - Participants' characteristics at baseline.

Categorical variable (sex)	Full sample		TBI		Stroke	
	Fr	%	Fr	%	Fr	%
Men	36	62.1	22	78.6	14	46.7
Women	22	37.9	6	21.4	16	53.3
Total	58	100.0	28	100.0	30	100.0
Quantitative variables	Mean		Mean		Mean	
	SD		SD		SD	
Age	47	13.35	43	14.12	52	11.05
Disease evolution (years)	4	3.65	5	4.15	4.20	3.05
Age at injury (years)	41	14.00	36	14.76	45.80	11.61
Global Deterioration Scale score	3	1.40	3.86	1.20	2.77	1.38
Glasgow Coma Scale score	14.89	0.31	14.89	0.31	-	-
Overall sample	Min/Max		M		SD	
ICF capacity	0-3	1	0.87			
ICF performance	0-3	1	0.92			
AMPS motor	-1.87 / 3.16	1.10	0.89			
AMPS process	-1.16 / 2.08	0.47	0.73			

Abbreviations: Fr=frequency; TBI=traumatic brain injury; ICF=International Classification of Functioning, Disability and Health; SD=standard deviation; AMPS=Assessment of Motor and Process Skills

impairment. We evaluated both *capacity*, which describes the individual's actions without the help of any support product, technology or assistance from third parties, and *performance*, which refers to daily actions executed in the individual's current environment with or without the use of devices or supporting products. Both concepts were evaluated by observation and through interview. The maximum score was 92, with higher scores corresponding to lower capacity and poorer performance.

The AMPS was administered to all the participants, in accordance with standardized testing procedures, by occupational therapists trained in its administration and calibrated as reliable raters (Fisher, 1993; Gitlin, 2001). Each participant chose and performed two AMPS tasks, which were familiar, culturally relevant or part of their typical routine. The assessors, observing the participant perform these tasks, scored each of the 36 motor and process skills on a four-point scale: 1=markedly deficient; 2=ineffective; 3=questionable; and 4=competent, according to the AMPS. The raw scores were entered into the AMPS computer program, version 2005. Using Rasch analysis, this program was then able to convert the person's ordinal raw AMPS skill item score into a linear continuum, which was reported in logits (log-odds probability units) according to the level of participant skill, the level of challenge inherent in the task, and the pre-measured assessor severity.

Both cognitive impairment and level of consciousness were measured with screening tests: the GDS (Reisberg et al., 1982) and the GCS (Gill et al., 2004), respectively. To determine the side of the unilateral lesion, reference was made to neuroimaging data: functional magnetic resonance imaging, computed tomography or positron emission tomography.

Procedure

All the patients (always in the same order) were administered both the AMPS and the IFC before and after the treatment in accordance with each scale's proposed standardized procedure. During the interim period the sample received occupational therapy sessions within a multicomponent intervention (the MCI-OT).

The study procedures were in accordance with the ethical standards of the Helsinki Declaration and were reviewed and approved by the research and ethics committees of the specialized centers (CEADAC and POLIBEA) where the patients were recruited. All the participants provided written informed consent.

Intervention protocol

During the 11-month interim period, each member of the entire sample received an average of 80 sessions of occupational therapy (50 minutes per session, two sessions a week). This intervention, led by an occupational therapist with experience in neurorehabilitation, was always conducted at the rehabilitation center where the participant had been recruited. The

treatment, in all the patients, was provided mainly in a clinical setting. Following Pedretti's theoretical model (Pedretti, 1996), the occupational therapy sessions focused on training tasks and occupations, according to the following scheme: enabling activities, purposeful activities and occupation. The first few weeks focused on enabling activities, training motor, perceptual or cognitive components that would be needed for occupational performance. Purposeful activities were added in the following weeks, which, in the clinical setting, included practice of activities such as peeling or cutting food, and dressing and undressing the upper body. Finally, interspersed with other activities, we worked through each patient's actual occupations, either at home or in the real-world environment (such as public transport). To achieve greater ecological quality, after completing the intervention the occupational therapist encouraged the participant to continue their routines at home. During this period of time, they continued to receive their other therapies, such as physical therapy, speech therapy and neuropsychology treatment.

Analysis

The data were analyzed using the SPSS version 19.0. The level of significance was set at $p < .05$. Differences between each condition were examined using repeated measures analyses with a non-parametric test (Wilcoxon test for related samples). Cohen's d (d) was used to measure effect size: d values of .20, .30, and .40 have been suggested to represent small, medium and large effect sizes, respectively (Cohen, 1988).

First, we obtained descriptive data: the frequency of the categorical variable, and the mean and standard deviation (SD) of the continuous variables. Second, we tested the occupational performance of all the subjects included in the study. The comparisons were made from a longitudinal perspective, analyzing functional changes after the MCI-OT in: i) the full sample, ii) the diagnostic groups, and iii) the hemisphere damage groups.

Results

Table I shows the participants' characteristics and the descriptive tests administered.

Longitudinal outcome measures

The results of the longitudinal analysis of the effects produced by the MCI-OT on occupational performance in the full sample revealed that all the variables except those in the AMPS motor skills scale showed significant changes after the intervention. The capacity part of the ICF showed the most statistically significant value ($p < 0.001$), although the effect values show no relevant clinical impact (Table II).

The longitudinal analysis of the effects produced by the MCI-OT on occupational performance in the

sample divided by diagnosis revealed that the stroke group showed significant results in ICF, considering both capacity and performance. However, the TBI group showed no statistical significance in performance (ICF), but only in the process skills scale (AMPS) (Table III).

Finally, the longitudinal analysis of the effects produced by the MCI-OT intervention on occupational performance in the sample divided by injured hemisphere gave the following results: the subjects with RH injury showed significant differences for ICF capacity and performance (Table IV). However, the LH-injured group showed less favorable results: in addition to the absence of statistical significance, the size of the effect was minimal, showing a lack of pre- to post-treatment variations (Fig.s 1, 2).

With regard to the AMPS scale, the mean score for motor skills was maintained, but not for processing skills; the effect size was low, but significant, in favor of treatment ($d = 0.11$) (Table IV).

Discussion

Functionality before and after treatment

According to recent data (Huertas-Hoyas et al., 2014), people with RH damage show a higher level of functional independence, capacity, participation and quality of performance, both before and after the MCI-OT intervention. However, these results would also be found in a control group, as other studies

corroborate (Bernspång and Fisher, 1995; Chestnut and Haaland, 2008).

These results are similar to those of other studies (Walker and Lincoln, 1991; Hartman et al., 2005; Poole et al., 2009, 2011) of occupational performance (making coffee, preparing a meal, dressing or tying shoelaces), which ascribe greater levels of independence to the RH group. Nevertheless, we do not exclude the possibility that each hemisphere can have specific deficits that increase the dependency in relation to the extent of the damage. This is described in the scientific literature of perceptual deficits and apraxia, in the RH and LH, respectively. However, if the sample is evaluated by etiology (stroke vs TBI), it seems that there are no functional independence differences between the two groups (Huertas-Hoyas et al., 2014). Accordingly, it is the hemispheric localization of the injury, and not its mode, that justifies functional differences.

Impact of the MCI-OT intervention

The results of this study on the effects of the MCI-OT intervention show that the data varied depending on the groups considered.

First, the results in the full sample show significant improvements postoperatively in all the variables, except motor skills, although the effect values indicated a poor clinical impact. The MCI-OT intervention was found to promote recovery of the functions altered by the ABI (be it traumatic or vascular in nature and occurring in either of the two

Table II - Wilcoxon test for related samples in the full sample.

	Pre-intervention		Post-intervention		z	Sig.	d
	Mean	SD	Mean	SD			
ICF capacity	1.35	0.88	1.22	0.96	4.6	$p < 0.001$	0.07
ICF performance	1.18	0.92	1.12	0.95	2.39	$p < 0.05$	0.03
AMPS motor	1.11	0.89	1.14	0.91	0.16	$p = 0.87$	0.01
AMPS process	0.48	0.73	0.63	0.66	2.22	$p < 0.05$	0.11

Abbreviations: ICF=International Classification of Functioning, Disability and Health; AMPS=Assessment of Motor and Process Skills; SD=standard deviation; z=Wilcoxon test; Sig=statistical significance; d=d of Cohen transformed correlation coefficient for the effect size estimate

Table III - Wilcoxon test for related samples in the sample divided by diagnosis.

	Stroke						TBI					
	Pre-intervention		Post-intervention		z	d	Pre-intervention		Post-intervention		z	d
	Mean	SD	Mean	SD			Mean	SD	Mean	SD		
ICF capacity	1.28	0.76	1.13	0.87	3.33**	0.09	1.44	1.00	1.33	1.04	3.14**	0.05
ICF perform.	1.10	0.80	1.02	0.81	2.70**	0.05	1.27	1.05	1.23	1.09	0.60	0.02
AMPS motor	1.17	0.45	1.10	0.50	0.84	0.07	1.03	1.21	1.17	1.22	1.03	0.06
AMPS process	0.56	0.82	0.68	0.65	1.04	0.04	0.39	0.63	0.57	0.68	2.23*	0.14

Abbreviations: ICF=International Classification of Functioning, Disability and Health; AMPS=Assessment of Motor and Process Skills; SD=standard deviation; z=Wilcoxon test; d=d of Cohen transformed correlation coefficient for the effect size estimate. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

hemispheres). This is also supported by other studies (Waehrens and Fisher, 2007; Legg et al., 2006; Kristensen et al., 2011). However, the results for precise motor skills indicate the need for more research of interventions using different techniques that might benefit them more. This lack of significance with regard to motor skills was found in all the groups analyzed in the present investigation. Mar et al. (2011) point out that a functional ABI impacts mainly on physical dimensions of quality of life, but also in terms of loss of roles and social dysfunction. Merrit (2011) indicates that the AMPS, which measures motor skills, provides information about the patient's need for assistance to live in the community, which is a value that reflects their functional profile. Consistently, other authors (Seo and Oh, 2009; de Pedro-Cuesta et al., 2011) identified mobility or motor aspects as featuring among the primary objectives of rehabilitation, due to the difficulty of recovery of these aspects. Moreover, there is evidence (Bernspång and Fisher, 1995; Nakayama et al., 1994) that intensive rehabilitation does not always result in an improvement in motor function, which implies that the intervention should also focus on enhancing compensatory strategies, and that motor function should be a priority in the planning stage.

Second, we studied the effect of MCI-OT in a group of people with stroke and in another group with TBI. In the first group (complete stroke sample), a therapeutic benefit was found in those scales that refer to ability and participation in daily activities (i.e. capacity and performance). Interestingly the lack of significance

with respect to processing skills corresponds to that found in a systematic review on the benefits of cognitive retraining in stroke patients (Hoffmann et al., 2010), which showed that the effectiveness of MCI-OT for improving cognitive sequelae of stroke remains uncertain, pending further investigation. However, other systematic reviews (Legg et al., 2007; Steultjens et al., 2015) found that post-stroke occupational therapy that focused on improving personal ADL, including cognitive and process skills, can improve performance and reduce the risk of deterioration in these abilities.

ABI rehabilitation must involve a multidisciplinary team and include specialists in neuropsychology as this is a discipline essential for the treatment of abnormal processing. Increasingly, neurological rehabilitation studies (Söderback and Normell, 1986; Holmqvist et al., 2009; Robey, 1998) are supporting the notion that improvement of cognitive components improves patients' daily functioning. The post-intervention analysis of the second group (complete TBI sample) showed a benefit of treatment on the variables of ability (capacity), level of independence and processing skills, without reaching statistical significance compared with the person's actual participation (i.e. ICF performance) in ADL. One possible explanation for this phenomenon is that it is due to a secondary benefit related to the clinical injury. In this case, the patient would benefit from the assistance provided by the family circle, close friends and the primary caregiver. This results in mutual satisfaction.

Figure 1 - Right hemisphere - benefit after MCI-OT.

Figure 2 - Left hemisphere - benefit after MCI-OT.

Table IV - Wilcoxon test for related samples in the sample divided by injured hemisphere.

	Right hemisphere						Left hemisphere					
	Pre-intervention		Post-intervention		z	d	Pre-intervention		Post-intervention		z	d
	Mean	SD	Mean	SD			Mean	SD	Mean	SD		
ICF capacity	0.96	0.80	0.73	0.78	4.63***	0.14	1.75	0.77	1.72	0.86	1.36	0.02
ICF performance	0.74	0.83	0.64	0.80	2.84**	0.06	1.63	0.80	1.60	0.86	0.53	0.02
AMPS motor	1.47	0.90	1.54	0.76	0.22	0.04	0.74	0.74	0.74	0.89	0.34	0.00
AMPS process	0.72	0.74	0.88	0.66	1.50	0.11	0.23	0.65	0.37	0.57	1.62	0.11

Abbreviations: ICF=International Classification of Functioning, Disability and Health; AMPS=Assessment of Motor and Process Skills; SD=standard deviation; z=Wilcoxon test; d=d of Cohen transformed correlation coefficient for the effect size estimate. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Third, after analyzing the full sample and the sample divided by diagnosis, we went on to test possible significant differences after the intervention according to the injured hemisphere (RH vs LH). The results were very similar to those obtained in the full sample; they showed greater benefit in almost all the variables in the RH group, although no great clinical impact was shown, as indicated by the effect values. Several authors (Bode and Heinemann, 2002; Zuchella et al., 2014) point out that rehabilitation may be more beneficial if it is started as soon as possible, in the acute or subacute stage with necessary clinical stabilization of the patient. People who have short periods of hospitalization have also been found to achieve better results. Toneman et al. (2010) indicate that functional rehabilitation can even be performed in the home with the same benefits as in hospital. Instead, the results of this study showed no statistically significant differences for patients with LH damage. This is not to say that these patients obtain no benefit from the treatment; in fact, the authors of a classic review on occupational therapy intervention in stroke (Legg et al., 2006) state that people receiving treatment “are less likely to deteriorate and ... more likely to be independent in their ability to perform personal activities of daily living”. However, to achieve maximum benefit it is first necessary to define the exact nature of the intervention. In the present study, it was seen that both groups derived benefit from MCI-OT, but that the RH-affected group was favored by the characteristics of cerebral asymmetry. Data from the present study suggest that the LH could be responsible for a good quality of occupational performance and level of functional independence in ABI subjects with RH injury. However, it is very important to remember that the hemispheres do not work in isolation. The brain is a network of constant intra- and interhemispheric communication, necessary in order to obtain the best quality at the lowest possible energy cost, and when the brain suffers damage in one of its hemispheres, it will seek to address, support and complement the affected area (either in one hemisphere or the other) in order to provide the highest quality of functionality and performance in the human daily habitat. This study has important limitations. Due to absences, vacation days or other causes, the subjects did not all receive the same number of sessions. Moreover, the fact that the overall sample received a multidisciplinary treatment, including physical therapy, speech therapy and neuropsychology treatment (and that we failed to take into account the contribution of each of these disciplines), means that we cannot attribute the benefit observed to occupational therapy alone. However, we know that this multicomponent intervention directly or indirectly affected the results. In addition, the sample size limits the possibility of drawing general conclusions. With regard to the clinical implications, these data show that hemispheric location and mode of injury (TBI or stroke) are the elements justifying the

functional differences observed and indicate that persons with ABI in the LH require more intense intervention, focusing in particular on aspects related to communication and social interaction. Motor skills have a lower permeability to the intervention, but the recovery of the same, especially walking, carries a high percentage of good prognosis for functional independence. Similarly, recovery of processing skills globally affects the functioning of the individual, enhancing his independence, and therefore becomes an extremely important target for inclusion in a rehabilitation program. The presence of a mismatch is possible between the values of capacity and performance in the same individual, so it is necessary to monitor this aspect and prioritize the search for a balance between the two.

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