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## INTRODUCTION

The prevalence of stroke continues to be high in western countries, despite the advances made in prevention and acute-phase care (1). Due to the aging population, this pathology is most frequent amongst elderly patients. Approximately 75% of strokes occur in patients over the age of 65, with incidence progressively increasing for each ten-year period from 55 years of age onwards (2).

Various studies have examined the rate of progress of patients recovering from a stroke, and their response to rehabilitation.

Although a great deal is known about the neurophysiological mechanisms responsible for recovery from neurological deficits, involving brain reorganization and the mechanism of neuroplasticity (3), a variety of functional recovery patterns have been described for patients with stroke sequelae by a range of authors (4-11).

Moreover, despite the great impact that strokes have on the elderly, little research has focused on the functional recovery pattern of the elderly specifically and it is therefore necessary for this to be clarified.

It is also essential to be able to call on assessment tools of proven effectiveness whose psychometric properties have been successfully tested on stroke patients. At the current time, a wide variety of measurements are used in post-stroke assessment. However, there is

as yet no consensus regarding the most suitable assessment scale or scales, with debate continuing with regard to the advantages and drawbacks of the different options available (12,13). Taking the foregoing into account, it seems that, in order to study patients' progress over time, a combined system of measurement which enables the global assessment of the patient is required.

Thus, this study seeks to establish the facts of the improvement over time of elderly stroke patients and, in order to do so, it makes use of a global assessment scale which can enable patient progress to be evaluated more precisely.

## **MATERIALS AND METHODS**

A total of 106 patients were selected for participation in this study (although 37 of them stopped receiving treatment for various reasons before the study was finished), 54.7% male and 45.3% female, with 67.9% having suffered an ischemic stroke and 32.1% a haemorrhagic stroke. The median age of the sample was 69 (most patients were between 65 and 75 years of age) and the median chronicity was 82 days. The mean values of the Barthel and FIM indices were  $30.20 \pm 2.73$  (range 0-99) and  $46.45 \pm 2.35$  (range 18-116), respectively, and the modified Rankin Scale (mRS) values ranged between 3 and 5.

The patients included in this study were  $\geq 65$  years of age and in a stable clinical condition, having previously suffered either an ischemic or haemorrhagic stroke in any area of the brain, but who had now overcome the acute phase of the illness. Patients with a diagnosis of congenital, perinatal or infantile hemiplegia, or hemiplegia secondary to intoxication or a brain tumour, were excluded. Patients in a very serious neurological condition (a vegetative or minimally conscious state according to the Coma Recovery Scale–Revised) were also excluded. Patients suffering from cerebellar syndrome or associated aphasia, as a consequence of the brain injury, were not excluded.

All those patients included in this study had been referred to the specialized rehabilitation service for brain injuries at the Hospital Valencia al Mar (part of the Hospitales Nisa group) between 2000 and 2010, having first been treated at various other hospitals, where a stroke had been diagnosed and where the patients had received acute phase treatment as part of a standard stroke treatment protocol.

### **Procedure and instruments**

Treatment was provided to each patient by a multidisciplinary neurorehabilitation program at the Hospital for at least a year. This facility provides organized stroke rehabilitation across a continuum of care, from the acute stroke service to return to home and community life. Our activity includes different programs focused on stroke rehabilitation across setting (acute hospital, inpatient rehabilitation facility, outpatient facility) and different professional rehabilitation disciplines (physical therapy, neuropsychology, occupational therapy, speech and language pathologist, etc.). The program usually includes acute and post-acute intensive inpatient multidisciplinary rehabilitation (up to 4-6 h/day of therapy) as

well as chronic low-intensity and/or home-based therapies, combined with specific community integration programs.

All patients admitted to our facility were assessed by a multidisciplinary team of clinicians with a standardized battery of 10 assessment tools which cover stroke induced impairment, function and activities of daily living (ADL), at three assessment times. This battery was administered at admission, and 6 and 12 months after admission. The complete battery included the following assessment scales (the range of possible values for each scale is shown in brackets, along with the name used to refer to them in the statistical analysis): Modified Barthel Index (0-100; Barthel); Lawton-Brody instrumental activities of daily living scale (0-8; IADL); Functional Independence Measure (18-126; FIM); UK FIM+FAM (Functional Assessment Measure) (30-210; FAM), Differential Outcome Scale (4-20; DOS); Glasgow Outcome Scale-Extended (1-8; GOS-E); Care and Needs Scale (1-8; CANS); Modified Rankin Scale (0-6; mRS); International Cooperative Ataxia Rating Scale (0-100; ICARS); National Institute of Health Stroke Scale, specifically the version which includes the assessment of the function of the hand (0-46; NIHSS).

Included scales were selected considering current guidelines and recommendations from national and international associations with special interest on neurorehabilitation, previous studies focused on stroke outcomes and the existence of validated versions in spanish population. All assessments were administered by licensed clinicians with more than 2 years of experience in neurorehabilitation who had been trained on these assessments and complete annual competencies on them.

The subjects of this study have signed their informed consent and the study protocol has been approved by the institute's committee on human research and it conforms to the Declaration of Helsinki.

### **Statistical methods**

Statistical analysis of the data was carried out using the Statgraphics Plus 5.1 software.

First of all, a normalized principal component analysis (PCA) was carried out in order to synthesise the diversity of information provided by the 10 assessment scales and define a small number of components which were able to characterise the greater part of this diversity. The objective was to be able to establish, for each assessment, a global health status measurement or index which was not conditioned by the nature of a single type of scale, and which could then be used to examine the stroke patients' progress over time.

Thus, the normalized components represent the weight each assessment scale takes in calculating the linear combination, which allows obtaining an overall score for each patient. It is precisely the magnitudes of these weights that allow a proper interpretation of the scores associated with each component.

Moreover, a two-way ANOVA (with the Assessment factor being the factor of interest and the Patient factor being the blocking factor) over the principal components obtained by the PCA, was realized.

## RESULTS

The results of the PCA, which are shown in table 1, synthesise the information provided by the different assessment scales in the form of two principal components, C1 and, the second component, C2.

Table 2 displays the results of the ANOVA, including the linear and quadratic effects of typical of quantitative factors, as the Assessment factor (time) is. It can be seen that the Assessment factor has a high level of significance, for both its linear and quadratic components (the p-values being extremely low).

Figure 1 provides a visual representation of the trajectory of the mean value (with the corresponding confidence interval being 95%) of C1 across the three assessments of patients.

This same analysis was carried out for each of the 10 assessment scales on which C1 was based (the results of which are presented in summarised form in table 3). It can be seen that, although not all of the scales show the same percentage change, there is a discernible similarity, both between the individual scales and with the global index, represented by C1.

## DISCUSSION

Regarding the first principal component obtained from the PCA, C1, it accounts for the larger part (71.8%) of the variability of the patients, and is taken to represent a combined index, summarising the information of the 10 assessment scales and expressing the overall health status (OHS) of the patient, with a higher score corresponding to a better health status. This interpretation is supported by the similar magnitude, in terms of the absolute values, of the coefficients associated with the different scales making up this first component, C1 (see table 1).

Other studies have used certain indices or neurological scales, such as the Scandinavian Stroke Scale (6), Level of Consciousness (5) or the Orpington Prognostic Scale (4), in order to define the neurological severity of the stroke or the patient's neurological status during the acute phase. Some authors (7) even use assessment functionality or dependence scales for the initial assessment, such as FIM, Barthel or the mRS, or scales for the assessment of cognitive-behavioural-emotional deficits, in order to quantify the severity of the post-stroke deficits.

However, in this study, we chose to use this combined C1 index, because it is able to make use of more complete and comprehensive information, and it is therefore more useful in order to gain an understanding of the severity of the patient's situation at each assessment point.



C2, which accounts for 8.4% of the patients' variability, compares the scales which assess the disturbances of bodily functions and structures and the limitations in carrying out activities (Barthel, FIM, FAM, mRS, ICARS and NIHSS) with the more comprehensive scales which offer an assessment which focuses more on the patient's level of participation (IADL, CANS, GOS-E and DOS), in accordance with the structure of the World Health Organization's (WHO) International Classification of Functioning, Disability and Health (ICF) (14,15).

The trend of the patients' progress, as measured by the C1 global index, can be identified via the results of the two-way ANOVA (tables 2 and 3). A high level of significance can be seen, for both the linear and the quadratic components; while the linear component shows a clear trend with regard to the improvement of the patients' general health over the 12 month rehabilitation period, the curve also makes it clear that the improvement was greater in the first six months (72.7%) than in the last six months (27.3%).

The results of the study of the patients' progress based on the 10 assessment scales show a high level of consistency with the results based on the general health of the patient (C1), with this pattern of improvement being observed to be more intense during the first six months of the rehabilitation period (table 3). Nevertheless, expressing the pattern of improvement observed by means of the assessment scales facilitates the interpretation of these findings, as these scales form part of the clinical language used across the world by health professionals.

The literature (3) accounts for this trend in the post-stroke recovery process, detailing the mechanisms which enable this recovery to take place. The early-stage recovery derives

from local processes, such as the recovery of the tissues surrounding the ischemic zone by means of the resolution of the edema surrounding the lesion, and the resolution of diaschisis (depressed function in brain areas connected with, but far away from, the damaged area). In contrast, improvement over the longer term, in which rehabilitation is more likely to play a significant role, is due to the reorganization of the nervous tissue and the mechanism of neuroplasticity.

The results of previous studies (4,5,7-11) are consistent with our findings, also showing upward post-stroke recovery curves whose trajectories become progressively shallower, being very similar to that of figure 1. This indicates the existence of an initial period of rapid recovery, followed by a stage in which improvement is less marked.

Despite this similarity to our results, not all of the researchers who have studied this trajectory of recovery have done so while considering the same time period. Some (4,7,9-11) have studied post-stroke progress for 12 months of treatment, as we have done, whereas others (5,6) have considered a shorter time period (six months). Of these studies, only one (4) has examined functional results at six-month intervals, taking into account assessments performed at the same times (0, 6 and 12 months) as in this study. Other researchers have frequently decided to establish intermediate assessment points, at one, two, three, four, six and 12 months (11,16,17), every months (5,10), or even every week from the commencement of rehabilitation (6,7,9).

Moreover, the majority of these studies (5-8,10,11,16), in contrast with the present one, defined an initial short-term stage of around three months which is characterised by a relatively rapid recovery rate. Some of these studies (6,7) also report that 80-85% of the

total recovery occurs during first month or month and a half, with 95% of the recovery having been achieved at three months. As well as reporting that the rate of recovery declines considerably after this initial period (three months), these studies also found, at the six-month stage, a stabilization period or plateau at which improvement became practically imperceptible in some cases. This was not the case in our study, which found that around 27% of the total recovery (up to 12 months) occurred between the six and 12 month assessments.

Thus, in the literature (6-8,11,16,17) we see that, improvements in some impairments observed after the first six months do not translate into significant functional improvement after this period. It seems that recovery of function may not be expected after six months post-stroke, and therefore it is at this moment that the set of symptoms are taken to have become stable. However, despite claiming the existence of this plateau in recovery, these studies also suggested that improvements in certain impairments can be detected after the first six months in certain cases such as in severely disabled patients (a year or a year and a half after the stroke occurred), and that, although these improvements become smaller and less decisive as time goes on, they provide justification for prolonging follow-up of stroke patients during the chronic phase in order to better characterise the adaptation of patients to their new functional situation.

This position is consistent with the findings of our study, as, although we have found the same trend in patients' progress, we have not found any stabilization period. It is possible that, had follow-up continued (i.e. beyond 12 months), such a stage would have been found – but not before the end of the twelve-month period. It is possible that the clear trend of improvement up to 12 months is linked to the advanced age and initial severity of the

assessments which is characteristic of our sample. In fact, some researchers (3,18) support this hypothesis, claiming that there is a proven link between the extent and rate of recovery and the initial severity of the patients' condition and their age. More specifically, they maintain that the extent and speed of the recovery are greater in younger patients, due to the negative effect that age has on the capacity to reorganize the damaged neurological connections.

Thus, it may be that the particular characteristics of the sample used for this study, (advanced age and high levels of chronicity and severity) cause the plateau to occur at a later stage (beyond the boundaries of this study), and that a more prolonged period of time may be necessary for those with more severe post-stroke impairment to achieve a given level of recovery.

A very recent study (19) has reported that one of the main factors contributing to the plateau in improvement is the phenomenon of neuromuscular adaptation to the standardized regimen for rehabilitation and exercise which stroke patients are typically assigned to. This study concludes that, when this type of adaptation occurs, it should not be assumed that the patient's recovery has reached an end, but rather further treatment alternatives should be used in order to facilitate recovery and sidestep the patient's adaptive state.

Moreover, it is worth pointing out that the plateau in recovery after the first few months may be partly due to the lack of sensitivity to change by a particular scale for at least some of the activities assessed. The fact that this study has used a combined index (OHS) for different assessment scales enables us to rule out the lack of sensitivity of the assessment tool as the possible cause of the non-observation of a plateau in the recovery trajectory of

elderly stroke patients: we have shown that, until now, no study has measured the functional recovery of patients over time by means of a combined OHS index. Yet it has still been possible to discuss our results with reference to those elsewhere in the literature as the improvement percentages attributed to the different periods are also provided in terms of the commonly used assessment scales. Most of the studies cited use a scale for the assessment of the ADL – the Barthel index (4-7,11), – although some have employed motor indices such as the Functional Ambulation Category, Fugl-Meyer Assessment or the Motricity Index (5,9) or neurological scales such as the Scandinavian Stroke Scale (6).

It has also been reported that, despite the fact that the recovery times are similar and that the general recovery trend does not vary, neurological and physical recovery occurs earlier than for ADL, as functional recovery in the latter case is a question of learning through practice and gaining confidence (6) and it may occur in the absence of neurological recovery (3). Such perspectives are to some extent compatible with the data reported in our study, as it can be seen that the percentage of improvement attributed to the first six months is slightly higher for the neurological scale (NIHSS) than for the functional scales (Barthel, FIM and FAM).

### **Study limitations**

This study had some methodological weaknesses. The results should be interpreted considering that this was a retrospective study, and there were possibly unmeasured sources of confounding bias as a result of individual therapists, differences in treatment selection or discrepancies among assessments. Specifically, all therapists involved in assessment were

also involved in the development, coordination and execution of each individualized rehabilitation program. This allowed the therapist to have precise information about patient's abilities and weaknesses but may have bias some of the scores.

## **CONCLUSIONS**

Elderly stroke patients who undergo a multidisciplinary rehabilitation programme lasting one year experience an initially rapid recovery period over the first six months followed by a less marked period of improvement. However, no evidence has been found of a plateau in the recovery of these patients during the first year of treatment. It is likely that elderly patients need a longer period of time in order to reach the same extent of recovery from stroke as that achieved by younger patients. Therefore, we suggest that this should be taken into account when establishing a prognosis for stroke patients and setting treatment schedules for elderly stroke patients.

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## FIGURE LEGENDS

Table 1 displays the normalised components (and their correlations with the scales in brackets) of the PCA performed on the scales used to assess the patient at the three assessment points.

Table 2 displays the ANOVA of the progression over time of the C1 component (OHS) which was obtained from the PCA of the three assessments.

Table 3 shows the distribution of the total change in patient assessment values between the two time periods (0-6 months and 6-12 months) for C1 and the 10 individual scales.

Figure 1 shows changes in C1 values over the three assessment points (1 for the assessment at admission, 2 for the assessment after 6 months, and 3 for the assessment after one year) over the course of the rehabilitation.

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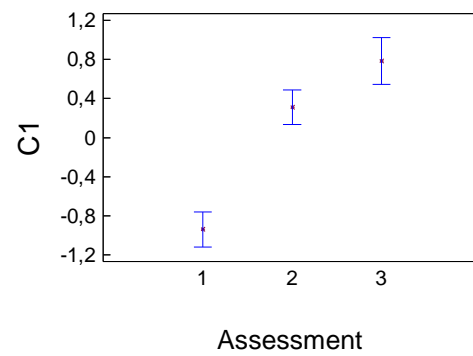
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**Figure 1.** Progression of C1 over the course of the rehabilitation.

Means and 95,0 Percent Confidence Intervals



**Table 1.** Normalized components of the PCA.

Assessment scales	Components	
	C1	C2
<b>Barthel</b>	0.348 (0.93)	0.259 (0.24)
<b>IADL</b>	0.310 (0.83)	-0.291 (-0.27)
<b>FIM</b>	0.358 (0.96)	0.131 (0.12)
<b>FAM</b>	0.355 (0.95)	0.076 (0.07)
<b>DOS</b>	0.329 (0.88)	-0.252 (-0.23)
<b>GOS-E</b>	0.266 (0.71)	-0.522 (-0.48)
<b>CANS</b>	-0.276 (-0.74)	0.390 (0.36)
<b>mRS</b>	-0.306 (-0.82)	-0.031 (-0.03)
<b>ICARS</b>	-0.308 (-0.83)	-0.418 (-0.38)
<b>NIHSS</b>	-0.291 (-0.78)	-0.403 (-0.37)
<b>% variability accounted for</b>	71.8	8.4
<b>% accumulated</b>	71.8	80.2

**Table 2.** ANOVA of the progression over time of C1.

Analysis of Variance for C1 - Type III Sums of Squares					
Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
<b>MAIN EFFECTS</b>					
A:Assessment	130.85	2	65.42	79.83	0.0000
Linear comp	119.29	1	119.29	145.56	0.0000
Quadratic comp.	11.56	1	11.56	11.56	0.0000
B:Patient	1640.93	103	15.93	19.44	0.0000
RESIDUAL	134.40	164	0.82		
<b>TOTAL (CORRECTED)</b>	1932.32	269			
All F-ratios are based on the residual mean square error.					

**Table 3.** Total change in patient assessment values.

Assessment scales	% change	
	0-6 months	6-12 months
<b>C1</b>	72.7	27.3
<b>Barthel</b>	73.8	26.2
<b>IADL</b>	64.8	35.2
<b>FIM</b>	73.1	26.9
<b>FAM</b>	71.4	28.6
<b>DOS</b>	68.5	31.5
<b>GOS-E</b>	75.3	24.7
<b>CANS</b>	68.7	31.3
<b>mRS</b>	70.3	29.7
<b>ICARS</b>	74.8	25.2
<b>NIHSS</b>	86.8	13.2